SHWG Report for Task 1 – Harmonized Means of Compliance for 25.562

1 - What is underlying safety issue to be addressed by the FAR/JAR?

The intent of FAR/JAR 25.562 is to provide an appropriate level of safety for passengers occupying aircraft seats. The differences in FAA and JAA means of compliance to Section 25.562 led to the need for harmonizing activity.

2 - What are the current FAR and JAR standards relative to this subject?

Current FAR text: **Sec. 25.562 Emergency landing dynamic conditions.**

(a) The seat and restraint system in the airplane must be designed as prescribed in this section to protect each occupant during an emergency landing condition when—
- (1) Proper use is made of seats, safety belts, and shoulder harnesses provided for in the design; and
- (2) The occupant is exposed to loads resulting from the conditions prescribed in this section.

(b) Each seat type design approved for crew or passenger occupancy during takeoff and landing must successfully complete dynamic tests or be demonstrated by rational analysis based on dynamic tests of a similar type seat, in accordance with each of the following emergency landing conditions. The tests must be conducted with an occupant simulated by a 170-pound anthropomorphic test dummy, as defined by 49 CFR Part 572, Subpart B, or its equivalent, sitting in the normal upright position.
- (1) A change in downward vertical velocity (Dv) of not less than 35 feet per second, with the airplane's longitudinal axis canted downward 30 degrees with respect to the horizontal plane and with the wings level. Peak floor deceleration must occur in not more than 0.08 seconds after impact and must reach a minimum of 14g.
- (2) A change in forward longitudinal velocity (Dv) of not less than 44 feet per second, with the airplane's longitudinal axis horizontal and yawed 10 degrees either right or left, whichever would cause the greatest likelihood of the upper torso restraint system (where installed) moving off the occupant's shoulder, and with the wings level. Peak floor deceleration must occur in not more than 0.09 seconds after impact and must reach a minimum of 16g. Where floor rails or floor fittings are used to attach the seating devices to the test fixture, the rails or fittings must be misaligned with respect to the adjacent set of rails or fittings by at least 10 degrees vertically (i.e., out of Parallel) with one rolled 10 degrees.

(c) The following performance measures must not be exceeded during the dynamic tests conducted in accordance with paragraph (b) of this section:
- (1) Where upper torso straps are used for crewmembers, tension loads in individual straps must not exceed 1,750 pounds. If dual straps are used for restraining the upper torso, the total strap tension loads must not exceed 2,000 pounds.
- (2) The maximum compressive load measured between the pelvis and the lumbar column of the anthropomorphic dummy must not exceed 1,500 pounds.
- (3) The upper torso restraint straps (where installed) must remain on the occupant's shoulder during the impact.
- (4) The lap safety belt must remain on the occupant's pelvis during the impact.
- (5) Each occupant must be protected from serious head injury under the conditions prescribed in paragraph (b) of this section. Where head contact with seats or other structure can occur, protection must be provided so that the head impact does not exceed a Head Injury Criterion (HIC) of 1,000 units.

  The level of HIC is defined by the equation:

$$HIC = \left[(t_2 - t_1) \left[\frac{1}{(t_2 - t_1)} \int_{t_1}^{t_2} a(t)\, dt \right]^{2.5} \right]_{max}$$

Where:

t1 is the initial integration time,
t2 is the final integration time, and
a(t) is the total acceleration vs. time curve for the head strike, and where (t) is in seconds, and (a) is in units of gravity (g).

(6) Where leg injuries may result from contact with seats or other structure, protection must be provided to prevent axially compressive loads exceeding 2,250 pounds in each femur.
(7) The seat must remain attached at all points of attachment, although the structure may have yielded.
(8) Seats must not yield under the tests specified in paragraphs (b)(1) and (b)(2) of this section to the extent they would impede rapid evacuation of the airplane occupants.

[Amdt. 25-64, 53 FR 17646, May 17, 1988]

Current JAR text: **JAR 25.562 Emergency landing dynamic conditions**
Date: May 27, 1994

(a) The seat and restraint system in the aeroplane must be designed as prescribed in this paragraph to protect each occupant during an emergency landing condition when—
   (1) Proper use is made of seats, safety belts, and shoulder harnesses provided for in the design; and
   (2) The occupant is exposed to loads resulting from the conditions prescribed in this paragraph.

(b) Each seat type design approved for passenger occupancy must successfully complete dynamic tests or be demonstrated by rational analysis based on dynamic tests of a similar type seat, in accordance with each of the following emergency landing conditions. The tests must be conducted with an occupant simulated by a 170-pound (77.11kg) anthropomorphic, test dummy sitting in the normal upright position:
   (1) A change in downward vertical velocity, (v) of not less than 35 feet per second (10.67 m/s), with the aeroplane's longitudinal axis canted downward 30 degrees with respect to the horizontal plane and with the wings level. Peak floor deceleration must occur in not more than 0.08 seconds after impact and must reach a minimum of 14g.
   (2) A change in forward longitudinal velocity (v) of not less than 44 feet per second (13.41 m/s), with the aeroplane's longitudinal axis horizontal and yawed 10 degrees either right or left, whichever would cause the greatest likelihood of the upper torso restraint system (where installed) moving off the occupant's shoulder, and with the wings level. Peak floor deceleration must occur in not more than 0.09 seconds after impact and must reach a minimum of 16 g. Where floor rails or floor fittings are fixture, the rails or fittings must be misaligned with respect to the adjacent set of rails or fittings by at least 10 degrees vertically (i.e. out of parallel) with one rolled 10 degrees.

(c) The following performance measures must not be exceeded during the dynamic tests conducted in accordance with sub-paragraph (b) of this paragraph:
   (1) Where upper torso straps are used tension loads in individual straps must not exceed 1750 pounds (793.78 kg). If dual straps are used for restraining the upper torso, the total strap tension loads must not exceed 2000 pounds (907.18 kg).
   (2) The maximum compressive load measured between the pelvis and the lumbar column of the anthropomorphic dummy must not exceed 1500 pounds (680.38 kg).
   (3) The upper torso restraint straps (where installed) must remain on the occupant's shoulder during the impact.
   (4) The lap safety belt must remain on the occupant's pelvis during the impact.
   Each occupant must be protected from serious head injury under the conditions prescribed in sub-paragraph (b) of this paragraph. Where head contact with seats or other structure can occur, protection must be provided so that the head impact does not exceed a Head Injury Criterion (HIC) of 1000 units. The level of HIC is defined by the equation –

$$HIC = \left[(t_2 - t_1) \left[\frac{1}{(t_2 - t_1)} \int_{t_1}^{t_2} a(t)\, dt \right]^{2.5} \right]_{max}$$

Where—

$t(1)$ is the initial integration time,

$t(2)$ is the final integration time, and

$a(t)$ is the total acceleration vs. time curve for the head strike, and where (t) is in seconds, and (a) is in units of gravity (g).

(6) Where leg injuries may result from contact with seats or other structure, protection must be provided to prevent axially compressive loads exceeding 2250 pounds (1020.58 kg) in each femur.

(7) The seat must remain attached at all points of attachment, although the structure may have yield.

(8) Seals must not yield under the tests specified in sub-paragraphs (b)(1) and (b)(2) of this paragraph to the extent they would impede rapid evacuation of the aeroplane occupants.

2a – If no FAR or JAR standard exists, what means have been used to ensure this safety issue is addressed?

FAR/JAR exist along with regulatory guidance material.

3 - What are the differences in the FAA and JAA standards or policy and what do these differences result in?:

The only difference between the FAR and JAR regulations is that the FAR is applicable to passenger and crew seats whereas the JAR is written against passenger seats only. This was not an issue for our group because we were tasked to work passenger seats and these are the seats for which there have been differing means of compliance to the regulations.

4 - What, if any, are the differences in the current means of compliance?

The FAA has accepted a "Revised Means of Compliance (RMOC)" which bases the test article selection process on a representative seat. The JAA method of compliance required a critical case selection for the test article.

5 – What is the proposed action?

Develop harmonized means of compliance based on a "family design" concept. This results in a simplified selection of a critical case seat(s) for certification. The process also allows for similarity comparisons to previously tested seats.

For each proposed change from the existing standard, answer the following questions:

6 - What should the harmonized standard be?

See attached concept paper for Task 1.

7 - How does this proposed standard address the underlying safety issue (identified under #1)?

Use of the principles in the concept paper result in an equivalent level of safety that is mutually acceptable by the FAA and JAA.

8 - Relative to the current FAR, does the proposed standard increase, decrease, or maintain the same level of safety? Explain.

The concept paper maintains the current level of safety. The regulation remains the same. The means of showing compliance has been standardized and clarified for all industry participants.

9 - Relative to current industry practice, does the proposed standard increase, decrease, or maintain the same level of safety? Explain.

The concept paper maintains the current level of safety. The means of showing compliance has been standardized and clarified for all industry participants.

10 - What other options have been considered and why were they not selected?:

Two alternative methods of demonstrating compliance were considered as follows:

a) The Revised Means of Compliance (RMOC) – Because this method of compliance relied upon a "representative" seat to test instead of a "critical case" seat the team felt that this approach was not consistent with the "intent" of the rule. Some key concepts, such as the Family of Seats, had significant value and were incorporated into the concept paper.

b) Traditional Critical Case Analysis – This approach, while still acceptable, as a method of compliance, was not bounded in a practical way. This led to much iteration of analysis and an inconsistent expectation in the amount of detailed analysis required for a certification program. The concept paper focuses the seat assessment on the primary load path that is consistent with the Tradition Critical Case Analysis, but outlines a clearer expectation on the type and detail of analysis required.

11 - Who would be affected by the proposed change?

The seat suppliers, airframe manufacturers, regulatory authorities and airlines would have the choice of using the new ARAC concept paper approach or using the Tradition Critical Case Method.

12 - To ensure harmonization, what current advisory material (e.g., ACJ, AMJ, AC, policy letters) needs to be included in the rule text or preamble?

AC 25.562-1a

FAA Letters issued by the Transport Standards Staff

- *FAA Memorandum dated April 30, 1993, subject: "Yaw angle for the Down Test in Dynamic Seat Test, Section 25.562".*
- *FAA Memorandum dated May 11, 1994, subject: "Seat Strength Policy for Section 25.562".*
- *FAA Memorandum dated March 13, 1995, subject: "Additional Guidance Concerning Dynamic Testing of Transport Airplane Seats".*
- *FAA Memorandum dated January 18, 1996, subject: "Pass/Fail Criteria for Section 25.562, Dynamic Testing of Seats".*
- *FAA Memorandum dated February 16, 1996, subject: "Simplified Procedure for Addressing the Head Injury Criteria of Section 25.562". Reference: Policy Letter TAD-96-002.*
- *FAA Letter dated May 8, 1996, subject: "Public Meeting Response". Reference: 96-114-3.*

- *FAA Memorandum dated November 17, 1988, subject: "Seat Tracks Approved for use in Dynamic Tests under 25.562"*
- *FAA Memorandum dated October 20, 1997, subject: "Guidance for Demonstrating Compliance with Seat Dynamic Testing for Certain Derivative Airplanes". Reference: 97-112-38*
- *FAA Memorandum dated November 19, 1997, subject: "Guidance for Demonstrating Compliance with Seat Dynamic Testing Deceleration Pulse Shapes". Reference: 97-112-43*

Although not required, it would helpful to the industry to update TSO C127 to allow use of the ARAC concept paper as a method of test article selection.

13 - Is existing FAA advisory material adequate? If not, what advisory material should be adopted?

The content of ARAC-SHWG Task 1 Concept Paper should be adopted as FAA guidance material.

14 - How does the proposed standard compare to the current ICAO standard?

Unknown at this time

15 - Does the proposed standard affect other HWG's?

No

16 - What is the cost impact of complying with the proposed standard?

There is no anticipated increase in the cost of compliance using this new method. Preliminary data suggests that the industry may experience a cost reduction, but this has not been substantiated at this time.

17. - If advisory or interpretive material is to be submitted, document the advisory or interpretive guidelines. If disagreement exists, document the disagreement.

All data for this task is contained in the attached concept paper.

18.- Does the HWG wish to answer any supplementary questions specific to this project?

No supplementary questions have been identified at this time.

19. – Does the HWG want to review the draft NPRM at "Phase 4" prior to publication in the Federal Register?

Yes. The ARAC-SHWG wishes to review the draft guidance material before it is adopted by the regulatory agencies.

20. – In light of the information provided in this report, does the HWG consider that the "Fast Track" process is appropriate for this rulemaking project, or is the project too complex or controversial for the Fast Track Process? Explain.

The Fast Track process is appropriate for this task.

SEAT HARMONIZATION WORKING

Concept Paper Vote

NAME	AFFILIATION	Task 1	Task 2	Task 3
Jurgen Feldhaus	Daimler Chrysler Aerospace Airbus	Accept 2/3/00	Accept 2/3/00	Accept 2/3/00
Ronda Ruderman	Association of Flight Attendants	Accept 2/7/00	Accept 2/7/00	Accept 2/7/00
Vahe Bilezikjian	B/E Aerospace	Accept 2/2/00	Accept 2/2/00	Accept 2/2/00
Francis S. Heming, Jr (Frank)	B.F. Goodrich Aerospace - AMI Seating	Accept 2/2/00	Accept 2/2/00	Accept 2/2/00
Uwe Johannsen	Daimler Chrysler Aerospace Airbus	Accept 2/2/00	Accept 2/2/00	Accept 2/2/00
Jean-Paul Deneuville	JAA	Accept 2/4/00	Accept 2/4/00	Accept 2/4/00
Jeff Gardlin	FAA	Accept 2/15/00*	Accept 2/4/00	Accept 2/4/00
Harald Merensky	Lufthansa	Accept 1/31/00	Accept 1/31/00	Accept 1/31/00
Thomas Amthor	Recaro Aircraft Seating	Accept 2/2/00	Accept 2/2/00	Accept 2/2/00
Nigel Smith	Rumbold	Accept 2/3/00	Accept 2/3/00	Accept 2/3/00
Nathan Wilson	Sicma Aero Seat	Accept 2/4/00	Accept 2/4/00	Accept 2/4/00
Martine SAINTE-MARIE	Sogerma	Accept 2/3/00	Accept 2/3/00	Accept 2/3/00
Jeanne Elliott	Teamsters Airline Division	Accept 2/7/00	Accept 2/7/00	Accept 2/7/00
J. Hugh O'Conner	Transport Canada	Accept 2/4/00	Accept 2/4/00	Accept 2/4/00
Tony Hobson	UK CAA	Accept 2/4/00	Accept 2/4/00	Accept 2/4/00
Daniel Freeman	Boeing	Accept 1/26/00	Accept 1/26/00	Accept 1/26/00
Nick Calderone	Boeing	Accept 2/1/00	Accept 2/1/00	Accept 2/1/00
Steven J.Hooper	J. B. Dwerlikotte Assoc., Inc	Accept 2/8/00	Accept 2/8/00	Accept 2/8/00
Stephen Soltis	FAA (through Gardlin)	Accept 2/15/00*	Accept 1/19/00	Accept 1/19/00
Clive Bradbury	British Airways	Accept 2/4/00	Accept 2/4/00	Accept 2/4/00
Laurent Pinsard	JAA-DGAC	Accept 1/31/00	Accept 1/19/00	Accept 1/19/00
Stefania Randisi	Registro Aeronautico Italiono (RAI-ENAC)	Accept 2/4/00	Accept 2/4/00	Accept 2/4/00
Gregory R. Thiele	Weber Aircraft Inc.	Accept 2/1/00	Accept 2/1/00	Accept 2/1/00
Antonio Fiordelli	Avio Interiors	Accept 2/4/00	Accept 2/4/00	Accept 2/4/00

* Accepted if the mandatory comments that were provided were incorporated into the concept paper.

1.0 Introduction

This concept paper has been developed to simplify and standardize the passenger seat test article selection process and pass/fail criteria for FAR/JAR 25.562. It presents a decision process to standardize the selection of seats based on simplified, critical case analysis. This concept paper is a further development of the concepts outlined in AC 25.562-1A, Section 6b "Selection of Test Articles".

Examples provided in this concept paper are intended to illustrate and clarify the technical principles. They are not intended to provide firm boundaries for interpreting the material.

The selection method outlined below employs a Family of Seats defined in Section 3.0. In order for individual seat part numbers to be covered by the baseline testing defined in Section 4.0, seat components are to be consistent in their design philosophy with allowable variations driven by:

- Geometric constraints within the seat structure (for example, attachment hardware may vary between the lateral beams and the seat legs due to differences in seat track buttock lines)
- Airplane interface (for example, seat back widths may vary depending on aisle width requirements)
- Other similar requirement.

However, these differences in the seats must be justified based on procedures outlined in Section 3.0. The family of seats must be established in order to use the test article selection process described in this document. The decision process outlined below defines the tests necessary to substantiate a family of seats. Additional tests or analysis may be required to justify seat components within the family, if new and unique features are part of the seat design or to expand the seat family.

The family of seats is a philosophy in design. A group of seats can be designed using the same design concept, or as separate entities (non-family members). If the components in the seat design are carefully considered in advance, the base line testing described in this document may substantiate the majority or all of the seat part numbers for compliance to FAR/JAR 25.562. Additional tests beyond the baseline may be required to substantiate variations in seat design that are beyond the basic family principals.

Structural criticality (as required per FAR/JAR 25.307(a)) and seat family definition are two closely related, but separate topics. The objective of the requirement is to test the critical structural configuration, i.e. the seat with the critically stressed components in the primary load path. Basic seat designs that share equivalent components in the primary load path, hence the seat family concept can facilitate assessments of structural criticality. The test program defined for a family of seats may need to be expanded if there are subsequent model additions to the family, which cannot be substantiated using previous test data or appropriate engineering analysis. The need for additional tests does not change the family concept, and does not invalidate the family definition.

The seat family is defined based on design characteristics. Structural criticality assessments determine, in part, the scope of the test program within a family, not between families. The respective discussions of seat family definition and structural criticality determination are intended to be complimentary. Determinations of structural criticality assume that the family of seats has been established, and that variations within the family will be substantiated either by tests or analysis. The decision whether to conduct tests or perform analysis is made based on the guidelines given, with the underlying assumption that such choices are made within a well-defined family. Therefore, a comparison between families to establish that one design is more structurally critical than another are beyond the scope of this paper, and are not recommended.

It is not possible to capture all possible design details or component configurations on a document such as this. The intent of this concept paper is to provide an understanding of the design and certification philosophy that has been harmonized for section FAR/JAR 25.562. Engineering judgement and interpretation applied to the design are acceptable as long as the principals of this document are the basis of that judgement.

Philosophically, the primary structural load path and other components that influence occupant injury criteria (e.g., HIC, shoulder restraint retention, etc.) are evaluated to generate the baseline certification tests. As much as practical, the other pass/fail criteria (e.g., lap belt retention, lumbar, egress, etc.) are assessed on tests that are conducted to show seat structural compliance. Additional structural tests should not be generated to evaluate parts of the seat that are not in the primary load path or influence occupant injury criteria. (For example, a test would not be conducted to evaluate the most critical load on a baggage bar if that is different than the most critical test for the seat structure.). The requirements of FAR/JAR 25.562 are satisfied by the substantiation of the structure through the baseline tests and the additional family tests outlined by this paper.

The following decision process should be applied in order to fully utilize the test article selection process outlined below:

Step 0 Fully understand the family concept as it applies to the design philosophy.

Step 1 Complete the seat structure design: understand, the geometric differences in seat components within the family. Define the primary structure for the family validation (which components are considered the legs, lateral beams, etc.).

Step 2 Determine test seats based on the selection of test articles outlined in Section 4.0 below. These are considered the baseline tests.

Step 3 Validate the test article selection by analyzing the primary load path as outlined in Section 4.0. Add additional tests if necessary to substantiate variations to seat components. Seat component variations should be addressed in one of three ways:

1) Establish equivalence for dynamic test purposes and no test will be required.
2) Establish criticality to determine if an added test(s) would be required.
3) Allow for bracketing the variation by test A new family should not automatically be the consequence of a requirement to evaluation the variation in a component.

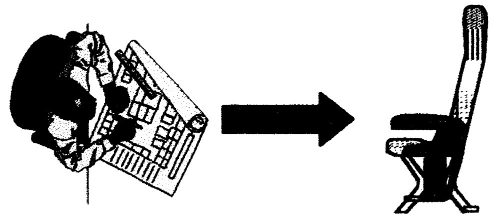
Iterate steps 1-3 as necessary.

Step 4 Perform testing.

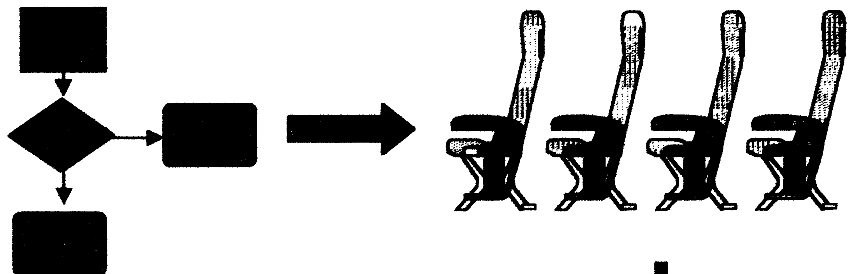
Step 5 For changes/modifications resulting from test failures, validate the test article selection by analyzing the primary load path as outlined in Section 3.0. Some previous testing (baseline and /or additional) may have to be re-run or additional tests may have to be added.

Step 6 Document the test results.

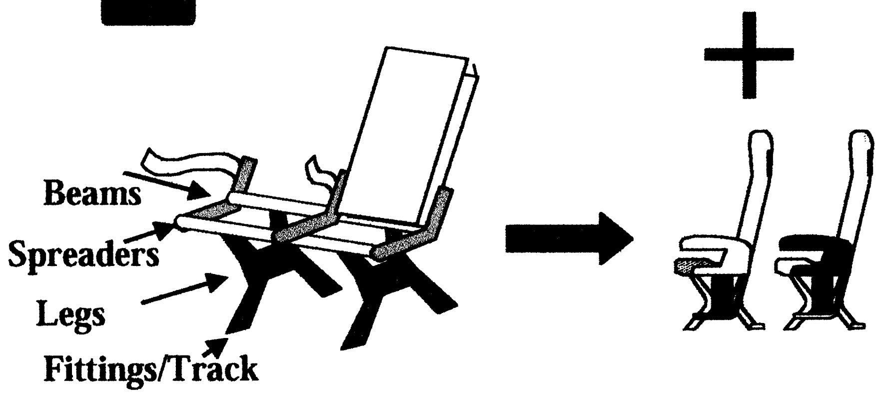
<u>**Step 1 - Complete Design**</u>



<u>**Step 2 - Determine baseline testing for seat famiy**</u>



<u>**Step 3 - Validate Family Concept - add additional tests if necessary**</u>



2.0 Definitions

These definitions are consistent within the context of this paper. It should be noted that these definitions should be checked for consistency with other guidance material.

A Family of Seats - a group of seat assemblies regardless of the number of seat places, built from equivalent components in the primary load path.

Rational Analysis - An analysis based on good engineering principles, judgement, and/or accepted methodology. This can include, but is not limited to, static/dynamic load comparison, static strength analysis, comparative static/dynamic strength analysis, engineering judgement linear static and non-linear finite analysis, and inspection.

Equivalent -Demonstrated to be comparable via analysis/testing for all aspects of intended function, performance, and related criteria.

Energy Absorbing Device - Load rate or peak load sensitive mechanism.

Primary Load Path - The components within the seat that carry the load from the point of load application to the structure that reacts the load from the seat system or sub-system.
Structural - from seat belt to fittings attaching seat system to airplane structure.
Lumbar - from bottom cushion to fittings attaching seat system to airplane structure.
HIC - from point of ATD head contact to seat back attachments.
Head Path - same as structural.

Similar Design Philosophy - A design which uses the same:

- Method of Construction (e.g., machined part vs. built up part),
- Detail part materials (alloys, heat treat, etc.)
- Manufacturing processes (machined, cast, etc.),
- Geometry, including section properties, except for minor differences resulting from space limitations within the seat or aircraft interface,
- Attachment method except for minor differences resulting from space limitations within the seat
- Load path

Typically, minor differences to geometry and attachment method must be shown to be equivalent to or less critical than the "baseline design" with regard to strength, stiffness, and seat permanent deformation.

Energy Absorber Rating - The amount of load required before the energy absorbing device initiates. The "highest rated" energy absorbing device would be the device that requires the highest load to initiate.

Beams - Lateral Beams - Cross Tubes - The lateral structural members that carry load across the seat frame from spreaders to seat legs.

Energy Absorber "Bottom-Out" - The energy absorber "bottoms out" when it reaches its maximum stroke and no longer provides an energy absorption function.

Occupant Position - This is assessed using the Seat Reference Point (SRP) as defined in AS8049 Revision A. Variations in SRP dimensions are in the component X, Y and Z directions The resultant change is not considered.

Instability Failure - An instantaneous loss of the load carrying capability of a structural member (e.g., the collapse of a column).

3.0 Family of Seats

A family of seats is a group of seat assemblies regardless of the number of seat places, built from equivalent components in the primary load path. Aft and side facing seats by definition are a separate seat family from forward facing seats.

The primary load path for structural tests typically includes seat components such as seat legs; lateral beams (cross tubes), spreaders, cushion supports and cushions, seatbelts and their attachments, attachments between structural members, seat track fittings and energy absorbers (Note: energy absorbers are normally integrated into the other seat components). The strength and deformation responses of these members are evaluated during structural tests.

The typical primary load path for lumbar load tests include bottom cushions, bottom cushion supports, and lateral beams (cross tubes). Also part of this load path are seat legs, spreaders, attachments between structural members, seat track fittings, and energy absorbers.

The typical primary load path for row-to-row HIC tests include components in the seat assemblies such as components installed on the seat back (e.g., food tray tables, video monitors, telephones, etc.), recline mechanism, breakover devices, seat back energy absorbers, seat back attachment hardware, and in some cases, arm rests.

The typical primary load path for head/knee path tests is the same as those for the structural tests.

In addition, some components (i.e., bottom cushions, bottom cushion support, armrests, and seat backs) affect the positioning of the occupant in the seat place that can influence ATD dynamic response and occupant injury criteria.

The discussion below describes common primary load-path components typically found in passenger seats. The components in the primary load path for each specific seat part number must be analyzed to ensure they fall within the family concept. Substantiation of variations to these components is also discussed below. These variations should be examined both between seat assemblies or within a single seat assembly.

While the discussion below addresses the evaluation of seat components as individual members, the dynamic performance of the entire seat assembly with all variations/modifications incorporated must also be evaluated against the tested seat assemblies. For example: a seat with variations from the tested seat in legs, beams *and* spreaders, might also require test, even though the change in any one element might not require test.

Seat Family Definition

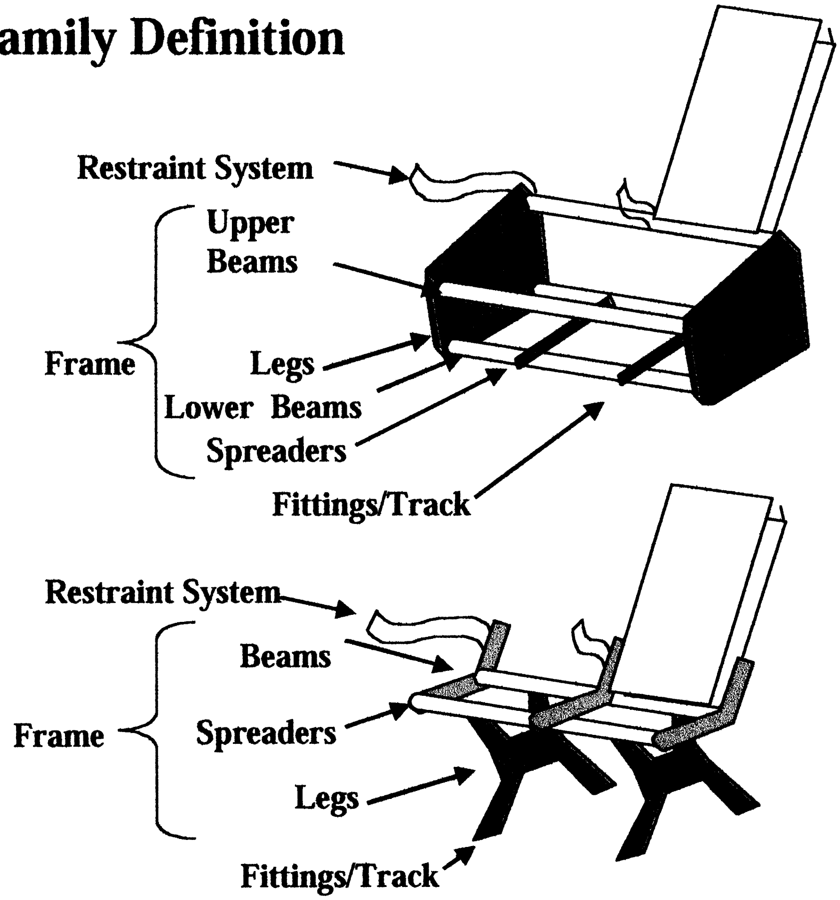
<u>Primary Load Path Elements</u>
Special tests should not be run addressing elements not on the primary load path. Aft facing seats by definition are a separate seat family from forward facing seats

Other Primary Load Path Elements
(not pictured)

Seat Back
(row to row HIC)
(Primary load path for aft facing seats)

Attach Fittings
(e.g. between spreaders and beams)

Bottom Cushion
Seat Pan



Each section below will be structured as follows:

- Description of the family concept/principles governing that component
- Discussion and guidelines for variations within the family, which are acceptable using rational analyses without test. This is generally for changes that do not make that feature more critical than the tested feature.
- Discussion and guidelines for variations in a seat family which will require test.

The usage of the term “variations” denotes variations and changes/modifications made post test, post certification, or resulting from failures.

3.1 Seat Legs

a) *Family of Seat Principles* - Seat legs are typically the vertical structural members of the seat that provide the load path from the upper seat structure (e.g. upper beams, pan, etc.) to the lower seat structure (lower beams, track fittings, etc.). Energy absorbers may be incorporated into the seat leg design (see section 9). To be eligible to belong in a particular seat family seat legs must have the same design philosophy, section properties, and energy absorber (if used).

Note: Seat track fittings that interface with aircraft structure are covered below.

b) *Variations and Post Certification Changes Acceptable by Analysis* - Variations to the seat leg geometry are acceptable without additional test(s) provided it can be shown by rational analysis that the strength, stiffness, and seat permanent deformation are equivalent to or less critical than the tested seat(s). For example, an increase in distance between the front and rear fitting would be acceptable provided it could be shown by rational analysis that (see appendix A):

- The floor fitting loads are equivalent to or less critical than the seat leg of the tested seat (e.g., linear interface loads analysis), and
- The strength of the portion of the leg that varies to accommodate the increase in distance is equivalent to or less critical than the seat leg of the tested seat
- The stiffness of the leg is similar to the critical leg in the longitudinal and vertical load conditions.

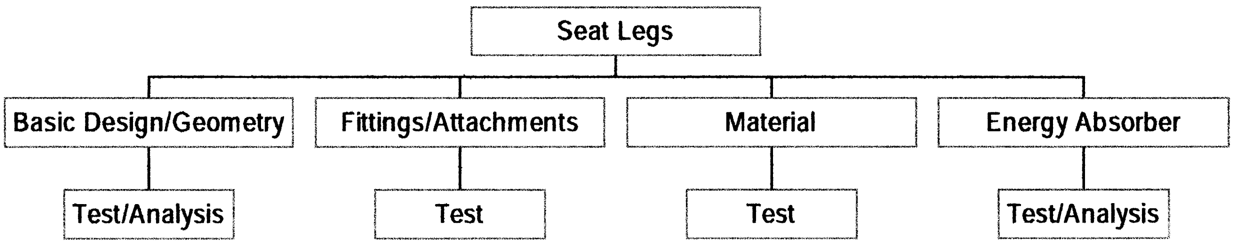
Holes or other minor variations to the seat leg that are not located in a highly stressed area are acceptable. For example, holes drilled in the leg web to attach under-seat electronics boxes are acceptable provided the hole is not in a highly stressed area of the leg.

c) *Variations and Post Certification Changes Requiring Additional Tests* - Additional tests would be selected based on the role that the variation plays in the seat performance. For example, a material change to a portion of the seat leg may require an additional 16g forward structural test, but not require additional HIC or lumbar tests.

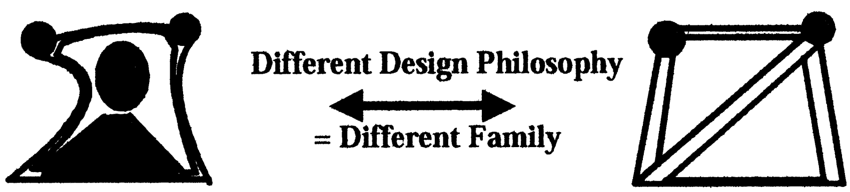
An additional test(s) must be performed for:

- Any seat with a seat leg geometry that is determined to be more critical with regard to strength, stiffness, or seat permanent deformation than the critical leg of a similar tested seat(s).
- Any seat with a seat leg energy absorber which has a variation in the load path, or which has a variation that affects the load rating or stroke/deformation of the energy absorber, from the seat(s) included in the baseline testing.

Static or dynamic component tests may be acceptable to substantiate variations to seat legs. Component test methods should be coordinated with the appropriate regulatory agency in advance of the certification program.



Note: Basic design/geometry includes small, local changes to the legs.
Fittings include attachments to cross-beams, fittings and spreaders.
Component tests may be appropriate instead of a full scale test.



3.2 Lateral Beams (Cross tubes)

a) *Family of Seat Principles* - Lateral beams (cross tubes) are typically the structural members that provide the load path from the fore-aft linkages (e.g., spreaders) and bottom cushion support to the vertical structure (e.g., legs). Lateral beams, at similar locations within the seat assemblies, must have the same design philosophy.

Two types of stiffeners are considered here. The first is a local doubler added to reinforce areas with high stress concentrations. A local doubler is defined as one whose length is of the same order of magnitude as the maximum cross-sectional dimension of the beam, e.g. one whose length is less than three times the maximum cross-sectional dimension of the beam. The second is a longer stiffener (e.g., nested tubes) used to increase beam stiffness and strength over a substantial part of the beam length. Lateral beams with long stiffeners should be treated as a different family, requiring a new, different test program since the dominant cross-section for the beam is different than other beams in the seat family.

Lateral beams can include local inserts within the family (e.g., doublers) which typically provide *local* strengthening of the beam. Inserts, at similar locations within the seat assemblies, must have the same material, manufacturing process and must have similar attachment methods. An insert configuration used in the primary load path (e.g., at the leg or spreader attachments) at all similar primary load path locations within the seat for all seats does not need additional substantiation beyond the baseline testing. For example, an insert included at any rear beam leg attachment should be included at all rear beam leg attachments for all seats in the family. Variations in geometry (length and thickness) are discussed below.

Nested tubes within a seat family must have the same material, manufacturing process and must have similar attachment methods. Variations in length are discussed below.

b) *Variations and Post Certification Changes Acceptable by Analysis* - The following variations in local inserts are acceptable without additional test(s) provided it can be shown by rational analysis that the strength, stiffness, and seat permanent deformation are equivalent to or less critical than the tested seat(s) (see appendix A).

- Insert thickness
- Insert length
- Insert location
- The elimination of a local insert in some locations of the seat assembly may be acceptable by rational analysis if the analysis *clearly* demonstrates the adequacy of the attachment without the insert.

Variations in the lateral beam length to accommodate differences in seat width are acceptable without additional test/analysis provided the seat is included in the interface load analysis used in the test article selection process in Section 4.0 of this concept paper.

Variations in nested tubes length and location are acceptable without additional test(s) provided it can be shown by rational analysis that the strength, stiffness, and seat permanent deformation are equivalent to or less critical than the tested seat(s).

c) *Variations and Post Certification Changes Requiring Additional Tests* - The structural performance of any seat with a lateral beam or nested tube possessing a variation in material, geometry (except for length), or manufacturing process from the seat(s) evaluated by test.

An additional test(s) must be performed for any seat that:

- Does not have lateral beam doublers, if used, at all similar primary load path locations within the seat,
- Has lateral beam doublersthat has a variation in material, geometry (except for length or thickness), or manufacturing process from the tested seat(s).
- Has lateral beam doublersor nested tubes which has a variation in length that is determined to be more critical with regard to strength, stiffness, or seat permanent deformation than the tested seat(s).
- Has lateral beam doublersor nested tubes that has a variation in attachment method that is determined to be more critical with regard to strength than the tested seat(s).

3.3 Seat Spreaders

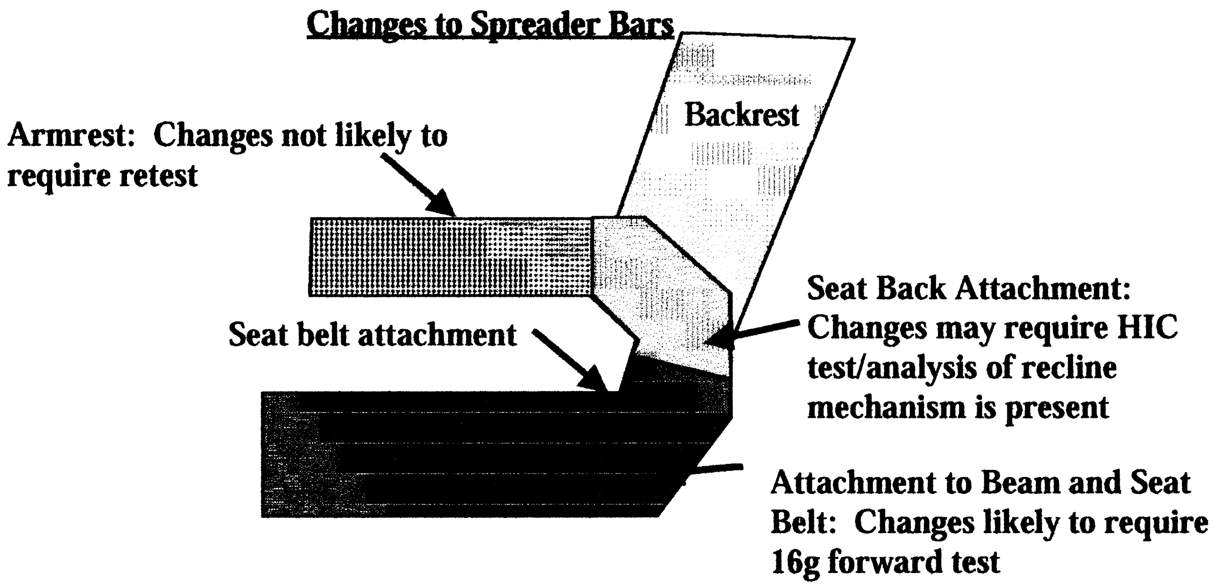
a) *Family of Seat Principles* - A Seat spreader is typically a fore-aft linkage between the lateral beams. Seat spreaders often provide the structural load path for other features of the seat (e.g., seat belt attachment, seat back attachment). Spreaders, at similar locations within the seat assemblies, should have the same design.

b) *Variations and Post Certification Changes Acceptable by Analysis* - Variations to parts of the spreader that are not in the primary load path (for example, between the seat belt/seat back attachments and the top of the armrest) are acceptable without additional test/analysis. For example, the area of the spreader that extends beyond the seat belt or seat back attachment that incorporates an armrest attachment. The armrest attachment may vary, provided:
   - The variation does not extend into the seat back/seat belt load path,
   - The variation does not affect any potential ATD head contact area from an occupant in the seat behind,
   - It can be shown by rational analysis that the retention of the armrest is not significantly affected.

   Variations to parts of the spreader that are in the primary load path (between the seat back attachments and the lateral beams/legs) are acceptable provided it can be shown by rational analysis that the strength (compression/bending) is equivalent to or less critical than the tested seat(s).

c) *Variations and Post Certification Changes Requiring Additional Tests* - An additional 16g longitudinal structural test must be added to the baseline testing for any seat with variations to parts of the spreader that are in the primary load path (between the seat belt attachments and lateral beams/legs).

   An additional row-to-row HIC test may be required, if variations to the spreader in any seat are within the ATD head contact area from an occupant in the seat behind or change the seat back performance with regard to HIC.



3.4 Bottom Cushion Support

a) *Family of Seat Principles* - The bottom cushion support (e.g., seat pan or diaphragm) is the structure immediately below the bottom cushion supporting the occupant weight. The primary considerations for this component regarding variations/changes are the affect on structural performance, lumbar load performance in a 14g vertical test, and the positioning of the occupant in the seat place. The bottom cushion supports at all seat place locations must have the same materials, manufacturing processes, construction method, and they must be similar in geometry and method of attachment, with the exception of section (b) below.

b) *Variations and Post Certification Changes Acceptable by Analysis* - Variations to the seat bottom cushion support geometry and method of attachment are acceptable without additional test(s), provided it can be shown by rational analysis, based on test data, that:
- The variations have no significant influence in increasing lumbar compression load (including deflection such that contact occurs with any item beneath),
- The strength is equivalent to or less critical than the tested seat.

The following variations are acceptable without additional tests:
- Variations in the bottom cushion support geometry to accommodate small difference in the seat place width (3 inches or less) provided other aspects of the geometry and the method of attachment do not vary.
- Variations in the bottom cushion support geometry having an influence on SRP location provided the SRP does not vary by more than 0.5 inch in any direction (fore, inboard, outboard, or up) from the SRP of the tested seat. In general, if all other features of a seat remain constant, head excursion with respect to the seat is shorter when the SRP moves aft. Similarly, structural loads due to overturning moments decrease as SRP is lowered. These general trends can be examined to eliminate duplication of some tests.

c) *Variations and Post Certification Changes Requiring Additional Tests* - Test(s) are required for any seat with a variation in seat bottom cushion support material or construction method from the tested seat(s).

Test(s) are required for any seat with a variation in seat bottom cushion support that has significant influence on lumbar load (including deflection such that contact occurs with any item beneath) or that is determined to be critical with regard to strength than the tested seat(s).

If a variation in the seat bottom cushion support varies the SRP more than 0.5 inches in any direction from the tested seat, the following tests/analysis must be performed:
- A 14g lumbar load test
- 16g longitudinal structural test if the SRP moves upward.
- 16g longitudinal head path analysis (if one is included in the baseline testing). This analysis would graphically modify the head path collected in previous test(s) to account for the change in SRP.
- A row-to-row HIC test should be performed if the SRP moves up or forward more than 0.5 inches. If the SRP moves down or aft, graphical analysis of the data collected in previous testing should be used to determine if the head might strike a different object.

Note: The new SRP location is directly related to any modification to the structural geometry in the seat bottom cushion support. Therefore, no SRP measurements are required in determining the "new" SRP.

3.5 Bottom Cushion

a) *Family of Seat Principles* - The bottom cushion is the component that the occupant sits directly upon. The primary considerations for this component regarding variations/changes are the affect upon lumbar load and the positioning of the occupant in the seat place. Occupant position is assessed using the Seat Reference Point (SRP) as defined in AS8049 Revision A or later. Variations in SRP dimensions discussed in this document are in the component X, Y, and Z directions (the XYZ resultant change is not considered). The bottom cushion assembly (i.e. foam sandwich) must have the same material (including density, material and manufacturing process, etc.), must be either molded or fabricated within a family, and must be similar in contour and thickness.

b) *Variations and Post Certification Changes Acceptable by Analysis* - Contour variations are acceptable without additional 16g & 14g structural tests provided the SRP does not vary by more than 0.75 inch in any direction (fore, aft, inboard, outboard, up or down) from the SRP of the tested seat. This 0.75 inches variation recognizes the inherent 0.25 inches tolerance in the SRP measurement in addition to an allowable design change of 0.5 inches. Experience has shown that geometry variations in an area three inches forward, two inches rearward and two inches sideward of each buttock reference point have the most influence on SRP.

   Variations in seat cover fabric are acceptable without additional analysis. This is provided the variations do not significantly affect the SRP location.

c) *Variations and Post Certification Changes Requiring Additional Tests* - An additional test(s) must be performed for:
   - Variation in bottom cushion material (excluding fabric and common fire-blocking material) would require a 14g vertical lumbar load test and 16g longitudinal head path test, if one were included in the baseline testing.
   - Variation in cushion contour that moves the SRP location more than 0.75 inches up would require a 16g longitudinal structural test.
   - Variation in cushion contour that moves the SRP location more than 0.75 inches in any direction would require a 16g longitudinal head path test, if one is included in the baseline testing.
   - Any variation in the cushion contour in an area three inches forward, two inches rearward and two inches sideward of the buttock reference point of the previously tested cushion would require a 14g vertical lumbar load test.

3.6 Seatbelts and Anchors

a) *Family of Seat Principles* - The seat belts (occupant restraints) provide the load path from the occupant to the seat structure. The seat belt typically consists of a latching mechanism, a belt anchor (which connects the belt to the seat) and webbing (which links the latch mechanism with the belt anchors). The latching mechanism must have the same materials, manufacturing processes, construction method, means of webbing retention, and must be similar in geometry. The belt anchors must have the same materials, manufacturing processes, construction method, and must be similar in geometry. The webbing must have the same material, manufacturing process, construction method, and geometry. The stitching used to attach restraint system hardware to the webbing must be identical to the tested seat(s).

The goal is to have standards for seat belts that are sufficient to reduce or eliminate full scale testing when they are substituted on a seat family. To date, there are not sufficient standards to accomplish this. At this time, one or more full scale dynamic tests would be required to substantiate a seat belt replacement.

The quality and workmanship of the restraint system shall be consistent with TSO/JTSO C22 or TSO/JTSO C114 or equivalent.

The seat belt anchor provides the load path between the belt anchor (part of the belt assembly) and the seat structure (e.g. spreader). Seat belt anchor, at similar locations within the seat assemblies, must utilize the same materials, manufacturing processes, exhibit similar geometry and employ similar methods of attachment.

b) *Variations and Post Certification Changes Acceptable by Analysis* - Variations to the seat belt anchor or latching mechanism, are acceptable without additional test(s) provided it can be shown by rational analysis that:

- The variation does not affect the means of webbing retention, and
- The strength and stiffness are equivalent to, or less critical than the tested seat.

Variations to webbing color, latching mechanism, belt anchor finish, part labeling, connector/buckle "handedness", latch handle disengagement angle, and adjustable-side webbing length are acceptable without additional analysis.

Variations of the fixed length of the restraint system is acceptable as follows:

- The adjuster mechanism moves closer to the centerline of a 50% ATD from the previously tested position (Unless the original position of the adjuster was at the extreme side of the occupant (i.e., at the anchorage point)).
- The adjuster mechanism moves to within ±1.5 inches of the centerline of a 50% ATD (reference FAA letter 96-114-3).

c) *Variations and Post Certification Changes Requiring Additional Tests* - An additional test(s) must conducted for any of the following variations if it is determined to be more critical with regard to the component's performance in the dynamic test compared to the tested seat:

- Changes in anchor geometry and method of attachment would require substantiation by test. Some changes to the seat belt anchor may be acceptable without test (e.g., changing a bolt to one with higher strength).
- Latching mechanism material
- Manufacturing process
- Construction method
- Stitch Pattern

An additional test(s) must be performed for any seat with a seat belt anchor which has a variation in material, manufacturing process, construction method from the tested seat(s)unless substantiated by analysis (above).

Variations in the webbing or means of webbing retention in the latching mechanism must be addressed by parametric studies during 16g longitudinal tests (structural, HIC, head path).

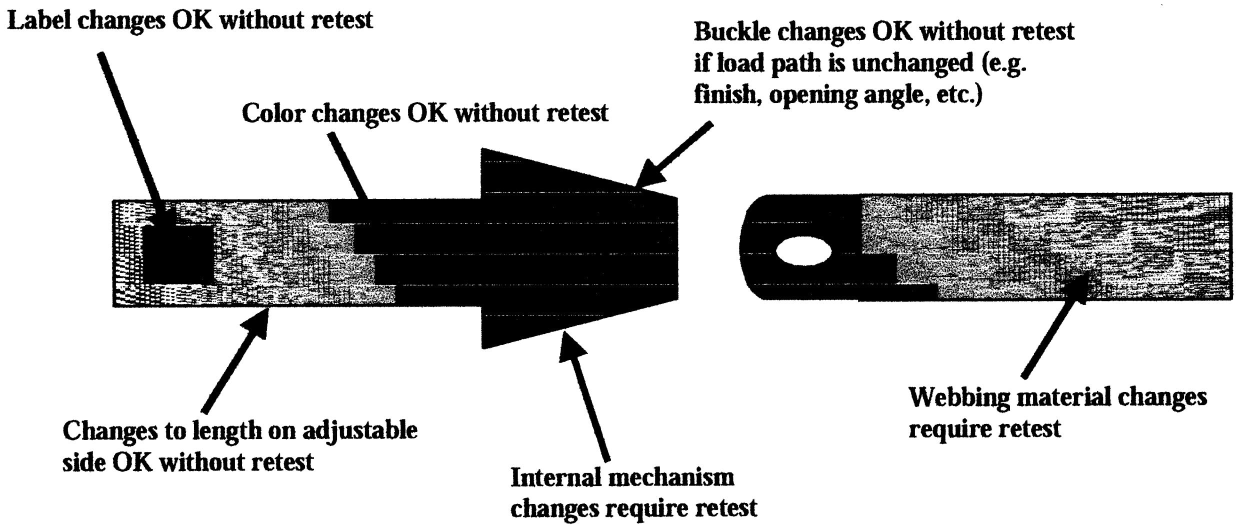
Once a belt system is qualified for a specific seat family it can replace other qualified belt systems on that same seat family. To qualify a new belt on an existing family, one 16g structural test seat with highest loaded leg (pitch and roll) must be performed. This structural substantiation is sufficient to allow use of the new belt on the seat family. The ATD head path must be compared for the seat with the new belt system and with the old belt system. This may be done on either the structural test noted above, or an additional 16g forward head path test depending on what data is available for comparison with the old belt system.

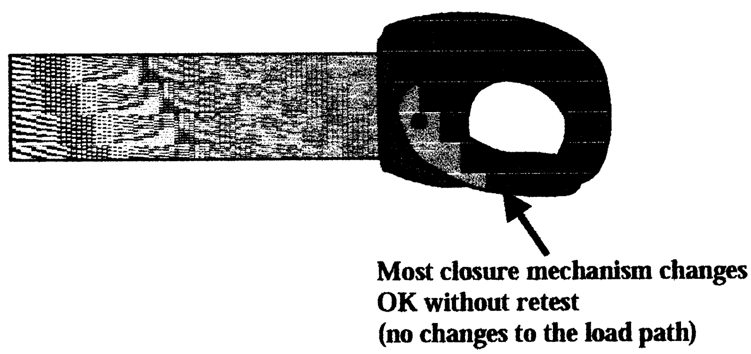
- If the head excursion along the entire path for the new belt system is equal to or less than the old belt system, no additional substantiation is required.
- If the head excursion along the entire path for the new belt system is greater than the old belt system, the installation limitations may need to be modified to account for this difference.

If multiple belts are a part of an existing seat family, and a seat component is changed in the family that will require additional testing, it is not necessary to retest with every seat/belt combination. Floor reaction loads for the 16g structural tests for each belt may be used in selecting a single belt for use on testing future changes to the seat family. This would cover all belts previously qualified using the same webbing material (e.g. nylon or polyester webbing). The belt used for this follow-on testing would be the one associated with the highest floor reactions.

Note: If the test using the new seat component generates significantly higher floor reaction loads (load increases on the order of 10% or more) compared to the test without the new seat component, the belts that were not tested must be addressed to ensure they have sufficient strength. A plan outlining additional test and/or analysis of the non-tested belts must be reviewed with the appropriate regulatory agency.

Seat Belts





3.7 Attachments between structural members

a) *Family of Seat Principles* - Fittings and fasteners provide the primary load path between structural components. These include, but are not limited to, the connection method of the spreader-to-beam attachment, beam-to-leg attachment, and leg-to-track fitting attachment. In general, these attachments should reflect similar design philosophy at similar locations within the seat assemblies (e.g. the attachment method between the lateral beams and the seat legs should be consistent between seat assemblies).

b) *Variations and Post Certification Changes Acceptable by Analysis* - Variations to the attachments between structural members due to space/geometry limitations are acceptable without additional test(s) provided
- The attachment has the same design philosophy, and
- It can be shown by rational analysis that the strength and stiffness are equivalent to or less critical than the tested seat.

c) *Variations and Post Certification Changes Requiring Additional Tests* - An additional test(s) must conducted for any seat with an attachment that reflects a different design philosophy (e.g., a beam-to-leg attachment with a spreader clamp design vs. a saddle design) from the seat included in the baseline testing.

An additional test(s) must be conducted for any seat with an attachment which reflects the same design philosophy but is determined to be structurally more critical than the attachment between structural members of a similar seat included in the baseline testing.

A single 16g longitudinal or 14g vertical test is sufficient to substantiate the attachment between structural members, with a different design philosophy or variations within the same design philosophy, provided it can be determined which test condition is critical for that attachment.

3.8 Seat track fittings

a) *Family of Seat Principles* - Seat track fittings are critical components in the primary load path.

The seat track fitting provides the load path between the seat primary structure (e.g., leg or beam) and the aircraft structure (e.g., seat track). Seat track fittings must have the same load path and similar design philosophy.

b) *Variations and Post Certification Changes Acceptable by Analysis* -

Variations to the seat track fitting locking mechanism engagement/adjustment device (screw, bolt, etc.) are acceptable without additional analysis provided it is not part of the load path, or does not change the load path (for example, by altering stud engagement).

Variations in seat track fitting finish are acceptable without additional analysis provided the method of finish application does not affect the strength of the part.

c) *Variations and Post Certification Changes Requiring Additional Tests* - Variations in seat track fitting geometry or method of attachment must be substantiated by test(s).

An additional test(s) must be performed for any seat with a seat track fitting which has a variation in load path, material, manufacturing process, construction method from the tested seat(s).

3.9 Energy Absorbers in Seat Leg Structures

a) *Families of Seat Principles* - Energy absorbers (EA devices) are typically incorporated in the seat leg structure to control occupant and/or structural loads. Within a family, energy absorbers must share a consistent design. While the incorporation of energy absorbing features is encouraged, the criticality assessment is not as straightforward as for other parts of the primary load path.

If all seat leg/EA combinations are identical, the normal seat dynamic test program that tests the structurally critical seat will also substantiate all the seat leg/EA combinations in this case. No additional tests are required.

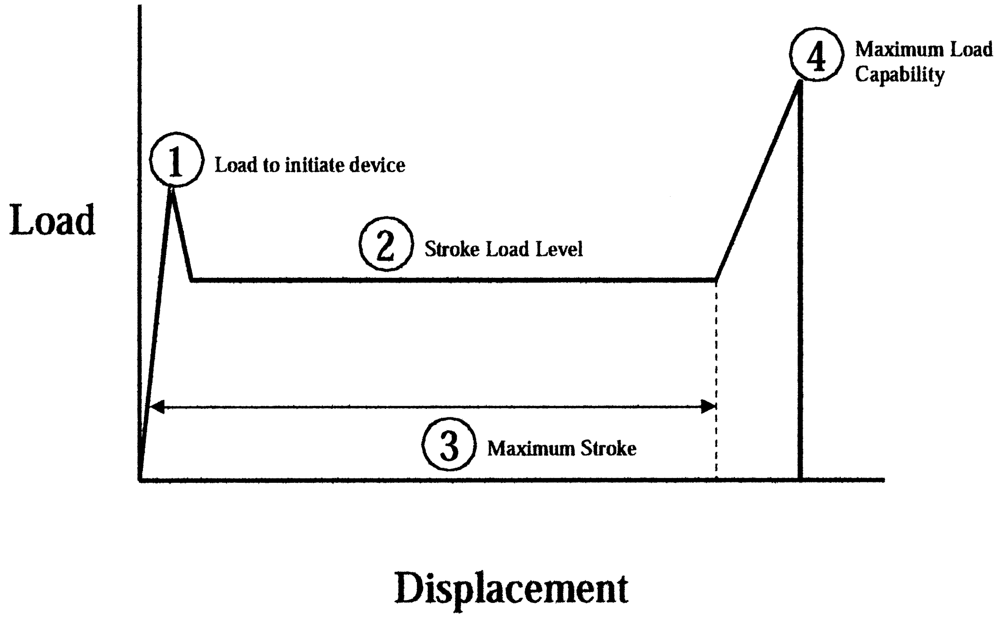
b) *Variations and Post Certification Changes Acceptable by Analysis* - When the seat leg structures are identical at all locations, but different rated EA's are at some seat leg locations (the EA's use the same design philosophy, and the EA's end attachments are identical), the leg structure must be substantiated for the highest load and the stroke of each EA device must be substantiated as follows:

<u>Substantiation of the Leg Structure and Attachment</u> - The normal seat dynamic test program that considers the structurally critical seat will also substantiate all the seat leg/EA combinations if none of the EA's stroke or if only the highest rated EA strokes. Either of these test results will ensure that the highest seat/floor interface loads were developed.

<u>Substantiation of the EA Stroke</u> - In general, a lower rated EA device should not 'bottom-out" unless the highest rated EA also "bottoms-out". In any event, additional tests may be required to test the lower rated EA device(s) in order to establish the highest seat/floor interface load for that device, should any EA other than the highest rated EA "bottom-out" during the test.

In all cases, additional tests must be performed, critically testing the lower-rated EA devices, or the supplier must work with the appropriate regulatory agency to develop a validated predictive model for the EA devices in order to provide an adequate rational analysis in order to avoid additional tests.

The following steps outline the considerations to be used in performing a predictive rational analysis used to substantiate seat legs with different rated EA devices. This analysis should be successfully completed prior to conducting dynamic tests in order to demonstrate that there is adequate testing of the energy absorbing system and the affected seat structure:



- The fundamental performance should be characterized in terms of the maximum load capability, the load to initiate the EA device, the stroking load level, and the amount of stroke/deformation available. These parameters all need to be determined.
- Using the static interface loads and knowledge of the EA characteristics the expected performance of each EA (i.e., stroking load level and stroke length) should be predicted;
- Correlate the analytical predictions and the results of the dynamic test to ensure that during the dynamic test all EA's have performed as designed.
- Demonstrate that none of the seat/EA combinations would bottom out under their maximum load case.

EA variations that do not affect the fundamental performance, or make the stroke/deformation of the EA more critical, may be allowed without retest.

c) *Variations and Post Certification Changes Requiring Retest* - If a seat assembly has different leg structure and different rated EA's at some locations, each seat leg/EA combination must be demonstrated by tests to produce that the maximum seat/floor interface load for each individual seat leg/EA combination. This is necessary to ensure that the maximum seat leg/EA load is developed for each combination and that adequate stroke is available at each individual EA.

3.10 Seat Backs

a) *Family of Seat Principles* - The seat back supports the occupant's torso in the seated position. It is the component of the seat that is typically forward of an occupant in a row-to-row HIC situation (forward facing seats), and is the component of the seat which provides the load path to the lower seat structure in aft facing installations. The permanent deformation of seat backs can be a significant consideration for the occupant egress of the airplane. The primary consideration for this component regarding variations/changes are the affects on seat back position/angle and occupant positioning (which may affect HIC or lumbar load), the affect on structural performance and seat back permanent deformation.

The components installed on the seat back (e.g., food tray tables, video monitors, telephones, etc.), must be represented when evaluating variations/changes, as well as the recline mechanism, breakover devices, seat back energy absorbers, and seat back attachment hardware.

The seat back structural components and attachment hardware must have the same materials, manufacturing processes, construction method and they must be similar in geometry.

The seat back energy absorbers must be the same for all seat backs for all seats that are subject to the HIC criteria.

The seat back breakover must be the same for all seat backs for all seats that are subject to the HIC criteria.

When a load is applied to the seat back in the upright position, the load path within recline mechanism(s) from the seat back to the seat structure must be the same for all seat backs that are subject to the HIC criteria.

The seat back breakover must be the same for all seat backs for all seats.

Seat backs should be interchangeable between most families if the seat back accessories, back structure and method of attachment perform the same.

Once substantiated for HIC, seat backs can be arranged independently in the aircraft (subject to pitch limitations of the target seats). For example, once the business class seats pass the HIC testing, they can be installed in the aircraft with an economy class seat behind without further substantiation. Exceptions include it being paired with a seat with very unusual performance (e.g. very large deformation, substantial energy absorption, etc.)

b) *Variations and Post Certification Changes Acceptable by Analysis* - Variations to components installed on the seat back are acceptable without additional test(s) provided the test article selection process in Section 4.0 (considering the component variance) shows the seat(s) selected for the row-to-row HIC tests are the seat(s) that was tested.

Variations to the attachment method of components installed on the seat back are acceptable without additional test(s) provided:

- For retention, it can be shown by rational analysis that the strength is equivalent to or less critical than the tested seat(s), and
- This does not replace the test in Section 4.0 for row-to-row HIC

Variations to the seat back, excluding potential head contact areas, which do not significantly affect the mass/weight, center of gravity or load path stiffness of the seat back (e.g., cushion trim, dress cover, etc.) are acceptable without additional analysis.

Variations of the seat back structure width up to two inches are allowed without additional test as long as these variations in seat width do not introduce new structure in the target head strike area. Variations greater than 2 inches may require additional test(s) for HIC and B/C deformation.

Variations in the seat back upright position of ±3° are acceptable without additional analysis provided it can be shown that the variation has no influence on occupant egress from the airplane when evaluated using the seat permanent deformation data from the baseline tests (reference AC 25.562-1A). For example, applying the seat permanent deformations from the baseline tests to the "new" seat back upright position still meets the guidance for occupant egress, including 'B' vs. 'C', given in AC 25.562-1A. Additional variations in the upright position are acceptable with analysis that the variations doe not influence HIC or egress for the person in the seat, or the person behind the seat.

Variations to backrest cushion hardness and contour are acceptable provided the SRP does not vary by more than 0.75 inch from the SRP of the tested seat.

Variations to any part of the recline mechanism which does not provide a load path from the seat back to the seat structure are acceptable without additional analysis.

c) *Variations and Post Certification Changes Requiring Retest* - Variations in the seat back structure materials, manufacturing processes, or construction method from the tested seat(s) may require retest.

A HIC test(s) must be performed for any seat with a seat back (subject to the HIC criteria) which has a variation in an installed component that the test article selection process in Section 4.0, when considering the component variance, shows must be tested in addition to the tested seat(s).

A test(s) must be performed for following seats if they are required to meet the HIC criteria:

- Any seat with a seat back that has a variation in the attachment method of an installed component that has been determined to be more critical than the tested seat(s).
- Variations in the seat back attachment method, which the test article selection process in Section 4.0 shows must be tested in addition to previously tested seat(s).
- Variation in the seat back energy absorber from the tested seat(s).
- Variation in the seat back breakover from the tested seat.
- Variation to any part of the recline mechanism which provides a load path from the seat back to the seat structure from the tested seat. If a part of the recline mechanism is not considered critical in the HIC load path, variations which do not lower the strength of the load path are acceptable without test. For example, the recline mechanism can be replaced with a "solid rod" because other components in the HIC load path absorb the energy of a seat back head strike.
- Variation in backrest cushion hardness or contour that varies the SRP location more than 0.75 inch in any direction from the seat back to the seat structure from the tested seat.
- Variation in the seat back upright position of greater than ±3° from the seat back to the seat structure from the tested seat, unless an acceptable analysis is provided per section (b) above.

3.11 Seat Weight

a) *Family of Seat Principles* - The seat weight has a significant influence on the seat performance during the structural tests. Small weight variations are acceptable, but large increases must be substantiated by test. These variations are accounted for in the critical test case evaluation by interface load comparison, and mass retention evaluation. Proper planning of test article definition and testing can make accommodation of future seat weight growth. This can be accomplished by adding ballast to the test article.

b) *Variations and Post Certification Changes Acceptable by Analysis* - An increase in the seat weight of a seat that was included in the baseline testing is acceptable without additional test/analysis provided the increase is not greater than 3% of the total unoccupied tested seat system weight. It is understood that 3% is the current focus of the SAE seat committee for weight increases without test. If the SAE committee selects an alternate criterion, this would be adopted as an acceptable standard.

An increase in the weight of a seat that was not included in the baseline testing (i.e., a seat that was not tested per the test article selection process) is acceptable provided:

- The test article selection process in Section 4.0, using a seat interface load analysis with the increased seat weight, shows the seat(s) selected for the structural tests to still be the tested seats.
- If the weight increase to any seat is due to adding a specific item to a specific location on the seat:
  - Retention of the added item must be addressed from the component to the primary structure of the seat:
  - For items where the strength of the attachment method is the only issue, a static analysis/test may be sufficient.
  - For items that are likely to affect the dynamic response of the seat, dynamic testing must have substantiated local retention of a similar item of representative weight and attachment.
  - Depending on the location of the added component, testing of the component in question for retention may be conducted on a partial or unoccupied seat. These types of tests should be coordinated in advance with the appropriate regulatory agency.
- Testing must have substantiated HIC if ATD head contact with the added item is possible.
- Testing must have substantiated lumbar load if ATD contact with the added item is possible.

c) *Variations and Post Certification Changes Requiring Additional Tests* - An additional test(s) must be added to the baseline testing for any seat that was included in the baseline testing with a weight increase greater than 3% of the unoccupied tested system seat weight.

An additional test(s) must be performed for any seat that was not included in the baseline testing with a weight increase if the test article selection process in Section 4.0, using a seat interface load analysis with the increased seat weight, determines that this seat should be selected for testing.

An additional test(s) must be performed for any seat with a weight increase due to adding a specific item to a specific location which was not substantiated in the baseline testing for retention of the item, HIC, or lumbar load (as appropriate).

A dynamic test of the seat with no occupants or a static test using an appropriate load factor may be acceptable to substantiate retention of an item of mass on the seat.

3.12 Armrests

a) *Families of Seat Principles* - Armrests are the seat structures that retain the occupant's sides. They are not required features on a seat and many passenger places can have armrests on one or both sides of the passenger stowed (folded up). They may influence the lumbar criteria in the 14g down test if the ATD's arms rest on them. The primary considerations for this component regarding variations/changes are the affect on retention of the component, HIC (head contact on aft part of armrest from occupant seated behind), occupant egress of the airplane (seat permanent deformations), and positioning of the occupant in the seat place.

b) *Variations and Post Certification Changes Acceptable by Analysis* - Variations to armrests are allowed provided:
- It can be shown by rational analysis that the variations have no influence on the ATD dynamic response.
- It can be shown by rational analysis that the variations have no influence on occupant egress from the airplane when evaluated using the seat permanent deformation data from the baseline tests (reference AC 25.562-1A).
- The test article selection process in Section 4.0, considering the seat with the armrest geometry variance, show the seat(s) selected for the row-to-row HIC tests have been tested
- Variations to the armrest attachment can be shown by rational analysis that the strength is equivalent to or less critical than the tested seat(s).

c) *Variations and Post Certification Changes Requiring Additional Tests* - Variations to armrests that are in a potential occupant head-strike location should be substantiated by test/analysis.

An additional test(s) must be added for any seat that has an armrest which has a variation in attachment method that is determined to be more critical with regard to strength than the seat(s) included in the baseline testing.

An additional test(s) may be required if changes to the armrests influence the ATD response to lumbar loads. For example, if the seat geometry forces the ATD's arms over the armrests during a test, and a post-test modification to the armrest would significantly change the ATD response, an additional test may be required.

An additional row-to-row HIC test may be required to be added, if geometry or material variations to the armrest in any seat are within the ATD head contact area from an occupant in the seat behind.

4.0 Test Article Selection for Baseline Tests

Test article selection from the family of seats is dependent on the installation and, in particular, the seat track. Installation on a different seat track will require re-substantiation and, in most cases, additional tests.

4.1 Structural Tests (reference section 25.562 (c)(7) and (c)(8))

Substantiation of the 16g longitudinal load condition for each family of seats:

1) Determine the 9g forward static interface loads (or any other standard load) for all seats. It is generally accepted that the interface loads calculated at 0° are sufficient to determine the most critical seat. Special seat design features *may* require interface load calculations that would take into account the aircraft tapered sections. All occupancy variations and combinations shall be considered for each seat (from unoccupied to fully occupied). The critical test case may be determined by analysis (FEM or static interface loads) and also by using test data.

2) Group the seats into two groups. Seats with two legs and seats with more than two legs.

3) For each group of seats (see attached decision chart to clarify the items below):

   a) Compare the aft fitting resultant loads of the seats within each group and identify the seat with the highest load. This seat will be tested.

   b) Subgroup the seats by lateral leg spacing.

   Note: For groups with more than two legs, define a subgroup of seats based on the minimum lateral leg spacing.

   c) Identify the subgroup with the minimum (narrowest) lateral leg spacing and identify the seat with the highest seat leg aft fitting resultant load within that subgroup.

   d) If the aft fitting resultant load of the seat identified in step 3c (narrowest leg spacing) is greater than 80% of the highest load found on the seat selected for test in step 3a then the seat identified in step 3c will also be tested. (See paragraph 6.b of AC25.562-1A and chart below).

   e) Conduct a 16g longitudinal dynamic test of each seat selected in steps 3a and 3d from each group. If the seats selected in steps 3a and 3d do not result in testing the seat with the most critical beam load, that seat should be tested as well.

f) The occupancy that produced the highest calculated seat leg resultant tension reaction in the aft fitting shall be used for the test, unless the load of the fully occupied seat is within 10% of the highest seat leg load. Due to the statically indeterminate nature of seat structure, there are assumptions used to calculate interface loads, which will result in some uncertainty. Data indicate that calculated reactions within 10% of one another are effectively equivalent. In such cases, a fully occupied seat will impart an overall greater load than a partially occupied seat. Therefore, if the fully occupied seat leg load is within 10% of the highest loaded seat leg, test the seat fully occupied.

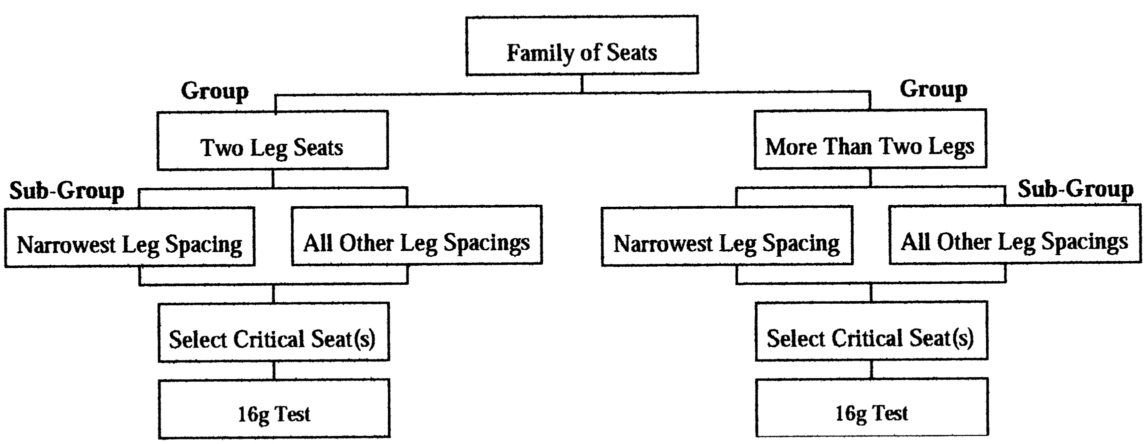
g) Select yaw, pitch, and roll for test setup per guidance given in AC 25.562-1A.

Note: If any seat in the family is intended to be installed on canted seat tracks, the yaw angle for the test shall be 10° plus or minus the aircraft installation cant angle (if it is more critical) depending on which yaw angle maximizes the calculated reaction (a test yaw angle other than the minimum required may be used to accommodate the test fixture adjustment capability).

h) Baggage, life vests, and literature pocket contents shall be installed at each seat place, regardless of seat occupancy. A floor for the ATD's feet is optional for the 16g forward structural test. The floor may remain flat, or follow the warpage of the seat tracks. (Reference AC 25.562-1A paragraph 11.f)

i) Retention of a specific item of mass, including emergency equipment, need only be demonstrated once during the 16g longitudinal load condition and the item of mass may be restrained for all other 16g longitudinal tests. (Reference AC 25.562-1A, paragraph 6.a).

16g Test



Structural Test Article Decision Tree

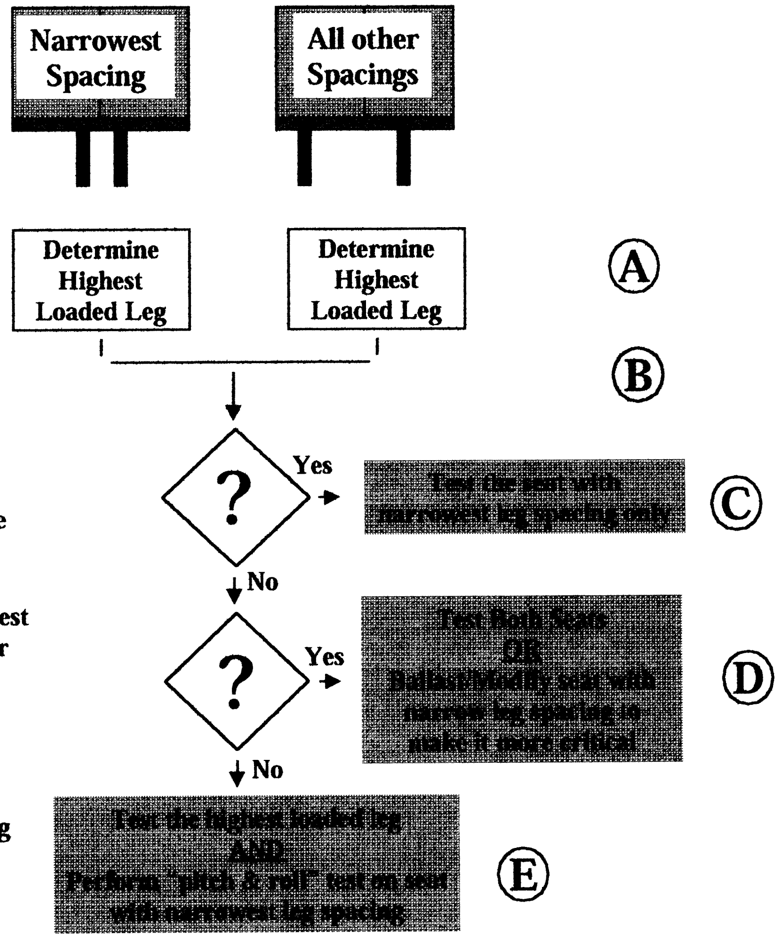
1) Determine9g Interface Loads

2) Compare the highest loaded legs

Question: Is seat with narrowest leg spacing the one with the highest interface loads in this group?

Question: Does the seat with the narrowest leg spacing have an interface load greater than 80% of the highest interface load in this group?

Final Choice: The highest interface load on the seat with the narrowest leg spacing is less than 80% of the highest interface load in this group.



(A) 9g static interface loads are the generally accepted indicator of seat structure criticality. Based on this analysis, the highest loaded leg will indicate the most critical configuration to test. (note: other features may drive criticality (e.g beam bending, etc.) in addition to the interface loads analysis). Using 9g static interface loads, identify the highest loaded leg for the seats with the narrowest leg spacing sub-group and the highest loaded leg for the seat from the wider spaced-leg sub-group(s).

(B) Compare the interface loads of the highest loaded seat leg from the sub-groups(s). It is generally accepted that the seat with the narrowest leg spacing will exhibit the highest pre-loads during "pitch & roll".

(C) By testing the seat with the narrowest leg spacing, the test covers the highest loaded leg and the highest pre-load from "pitch & roll".

(D) If the static interface loads for the seat with narrowest leg spacing is within 20% of the seat with the wide leg spacing, it cannot be easily determined which is the more critical to test. The pre-load from "pitch & roll" contributes more to the criticality of the seat with narrow leg spacing. Since the most critical seat cannot be easily determined, either test both seats, or modify/ballast the narrow seat so that it has the more critical interface loads and the highest pre-load from "pitch & roll". Test only the narrow seat. (Note: modification of the seat should be limited to relocating seat legs along a beam to create a more critical overhang. Modifications should not change seat hardware).

The 20% margin guideline was established from industry test data and represents a conservative estimate of leg pre-load forces over a large change in seat leg pitch. This number may be established uniquely for each seat family. Ideally, this value would be established based on pre-load test data compared to the peak resultant load from a 16g longitudinal test. A new ratio would be established for a seat model from test data as follows:

$$\text{Ratio} = \frac{\text{Pre-load test data (resultant load)}}{\text{Peak resultant load from 16g longitudinal test}}$$

(E) If the highest static interface load on the seat with the narrowest leg spacing is less than 80% of the highest loaded seat in this group, it can be assumed that the narrow seat with the higher pre- load will not be more critical. Only the seat with the highest leg load need be dynamically tested. A check must still be made on the narrowest leg spacing seat to ensure the structure has enough flexibility to accommodate floor warpage. This seat should be placed on a static test fixture and the floor warpage applied. No dynamic test of this configuration is required. This is a test of the primary structure. No ATD's or other additions to test article/set-up are required.

<u>For each family of seats, to substantiate the 14g down load condition:</u>

1) Compare the aft fitting resultant loads of all seats in the family, regardless of the number of legs on the seat, and identify the seat with the highest load. This will usually be the same seat that was selected for the critical forward structural test. This one seat will be tested.

2) Conduct a 14g vertical dynamic test of the seat selected in step 1.

   a) Full occupancy shall be used for this test. (Note: This is to ensure the maximum compressive load is put on the structure).

   b) Life vests and literature pocket contents shall be installed at each seat place, regardless of seat occupancy. Ballast may be used for non-critical parts of the seat (e.g., under seat In-Flight Entertainment (IFE) boxes, etc.). However, if this test is also used to acquire lumbar loads, the criticality of parts should be assessed with that in mind. See discussion in section 4.3 regarding compliance with FAR/JAR 25.562(c)(2).

   Note: Weights representing under-seat baggage are not required for the 14g vertical test. The ATD's identified in the FAR/JAR 25.562(c)(2) part of this test selection process shall be instrumented to collect lumbar loads.

   c) Retention of a specific item of mass, including emergency equipment, need only be demonstrated once during the 14g vertical load condition and the item of mass may be restrained for all other 14g vertical tests.

   Note: Refer to AC 25.562-1A to address special design features (e.g. unique energy absorption features).

A representative floor shall be included in the test set up for the ATD(s) feet.

4.2 Deformation for Egress

The seat permanent deformations (reference AC 25.562-1A Appendix 2) shall be measured in all tests in order to show compliance to 25.562(c)(7). In addition, seat back permanent deformations shall be measured in a test where the ATD head contacts the seat back (e.g., a row-to-row HIC test). These permanent deformations shall be used to show compliance to 25.562(c)(8). (Note: Deformations that are an artifact of test set-up orientation need not be considered.) Some of the seat permanent deformations will be evaluated for acceptability as part of the dynamic test results (seat pan rotation, 'B' vs. 'C'). Some of the seat permanent deformations will be used by the seat installer to evaluate the seat installation and aircraft interior configuration (seat forward, aft, side deformations, seat back forward and aft deformations, and deployment of deployable items). The seat installer shall use the seat permanent deformations to show an acceptable installation with regard to occupant egress of the airplane.

4.3 Occupant Injury Criteria (reference FAR/JAR 25.562 (c)(1-6))

<u>FAR/JAR 25.562 (c) (1) - Upper Torso Restraint Tension Loads</u>

The upper torso restraint tension loads shall be collected during a structural test where the seat is yawed in the direction that produces the highest tension load in the restraint system. Typically this is the yaw direction which puts the upper torso restraint over the shoulder of the ATD which is moved further forward as a result of the yaw.

If the 16g longitudinal test that demonstrates compliance to FAR/JAR 25.562(c)(7) is yawed in the appropriate direction, the restraint tension load data may be collected during this test and an additional test is not required.

If the 16g longitudinal test that demonstrates compliance to FAR/JAR 25.562(c)(7) is not yawed in the appropriate direction, an additional test must be added to the baseline testing. The test article for the additional test would be the same seat selected for the 16g longitudinal test that demonstrates compliance to FAR/JAR 25.562(c)(7). It would be yawed in the direction that creates the highest tension load in the restraint system, with the pitch and roll selected per the guidance in AC 25.562-1A.

FAR/JAR 25.562 (c) (2) - Lumbar Loads

1) The ATD lumbar loads shall be collected during the 14g vertical test that demonstrates compliance to FAR/JAR 25.562(c)(7). An additional test for collecting lumbar loads is not required in the baseline testing (except as noted below).

   a) ATD's instrumented to measure lumbar loads shall be placed in seat places which represent the stiffest load path from the center of the occupant place to the structure and the least-stiff load path from the occupant place to the structure. This requirement will typically result in two instrumented ATD's, but will not exceed three instrumented ATD locations in a single test.

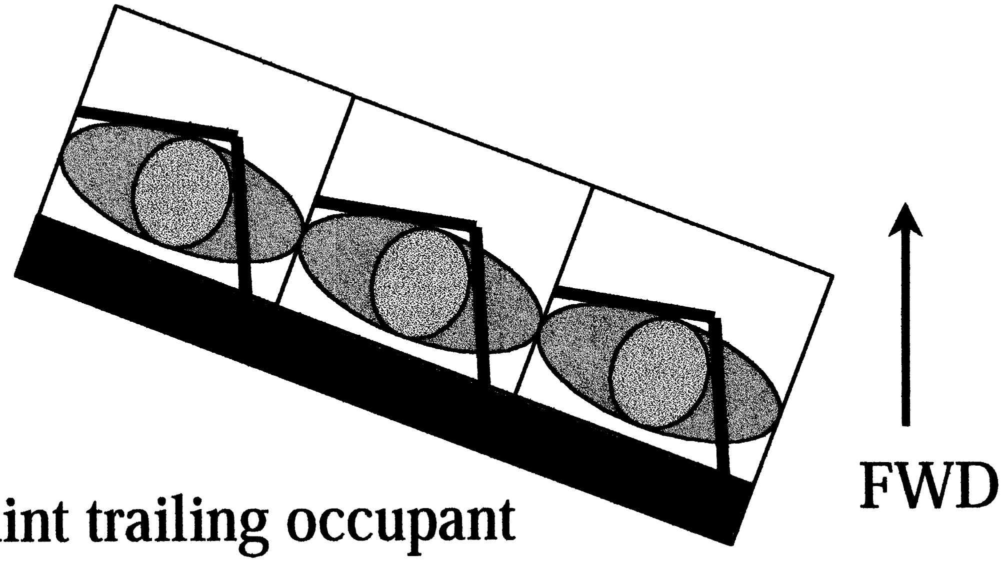
Note: Refer to AC 25.562-1A to address special design features (e.g. unique energy absorption features) which may function differently, depending on seat occupancy.

If there is an item (e.g. IFE) or structure located at a specific seat place (typically beneath the seat pan) which may influence lumbar loads due to seat deflection and/or ATD contact, then lumbar loads must be addressed and substantiated for this location in addition to the locations identified above (either data showing no contact or an additional test(s) added to the baseline testing).

FAR/JAR 25.562 (c) (3) - Upper Torso Restraint Remains on Shoulder

For seats with a single upper torso restraint (e.g. a 3-point restraint), a test which demonstrates that the upper torso restraint strap remains on the ATD's shoulder during impact with the seat yawed in the most critical direction must be conducted. Typically, this is the yaw direction that puts the upper torso restraint over the shoulder of the ATD that is moved aft as a result of the yaw.

If the 16g longitudinal test which demonstrates compliance to FAR/JAR 25.562(c)(7) is yawed in the appropriate direction so that the restraint is over the trailing shoulder, the restraint retention may be demonstrated during this test and it is not required to add a test to the baseline testing.



Restraint trailing occupant
(Overhead view)

If the 16g longitudinal test that demonstrates compliance to FAR/JAR 25.562(c)(7) is not yawed in the appropriate direction, an additional test must be performed. The test article for the additional test would be the same seat selected for the 16g longitudinal test. This demonstrates compliance to FAR/JAR 25.562(c)(7), yawed in the direction most critical for the restraint strap to remain on the ATD's shoulder, and with the pitch and roll selected per the guidance in AC 25.562-1A.

For seats with a dual upper torso restraint, the 16g longitudinal test which demonstrates compliance to FAR/JAR 25.562(c)(7) is acceptable for demonstrating the upper torso restraint straps remains on the ATD's shoulder during impact and it is not required to add a test to the baseline testing.

High-speed test film/video of the test will be used to demonstrate that the upper torso restraint strap remains on the ATD shoulder during the impact.

<u>FAR/JAR 25.562(c)(4) - Lap Belt Remains on Pelvis</u>

The baseline and additional tests will demonstrate the pelvic restraint remains on the ATD pelvis during the deceleration pulse. It is not required to add any tests to the baseline testing.

High speed test film/video of all tests (baseline and additional) will be used to demonstrate that the pelvic restraint remains on the ATD pelvis during deceleration pulse. No additional tests are necessary to show compliance with this paragraph. Current guidance outlines camera placement and quantity if the lap belt angle is greater than 55° or less than 45°.

FAR/JAR 25.562 (c) (5) - HIC

1) Seat-to-Seat HIC

In an effort to reduce the regulatory burden and simplify/clarify the procedure for demonstrating compliance, the following procedure has been developed. This procedure should allow demonstration of compliance for HIC with two tests in the majority of cases. The procedure takes into account seat pitch, the relative position of the seat and the row behind it as well as range of occupant sizes. The intent of this procedure is to provide default conditions that can be used in lieu of conducting several tests, or performing lengthy analytical studies, and is adequate to demonstrate compliance.

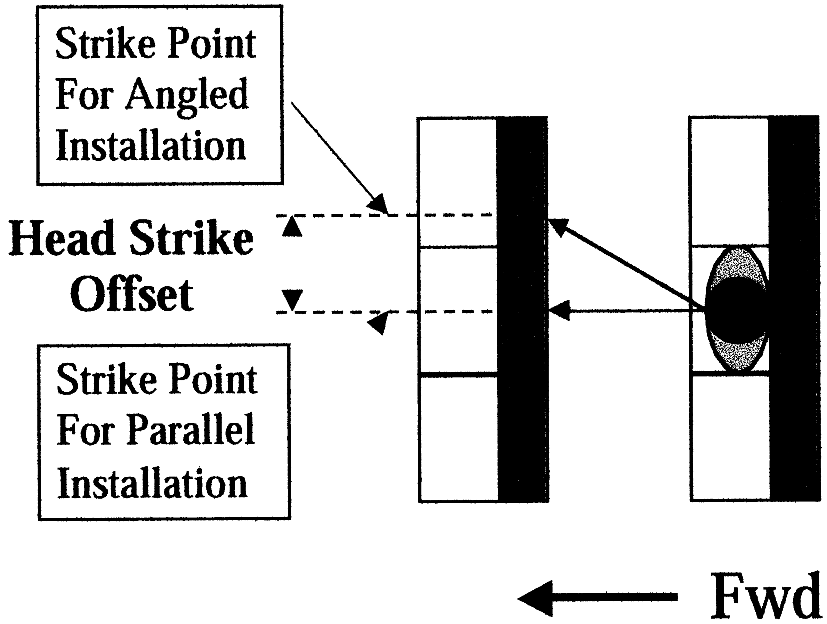
For each family of seats:

a) Identify the intended seat installation configurations from a seat-to-seat HIC perspective. This may include, but is not limited to:
   i) Seats on canted seat tracks, such that the seats are parallel, but are at an angle with respect to the airplane longitudinal axis.
   ii) Seats on staggered seat tracks such that the seat places, row-to-row, are staggered.
   iii) Non-parallel seat rows.
   iv) Staggered seating due to a change in the number of seat places.
   v) Different width seats which result in the seat places, row-to-row, to be slightly staggered.

b) Identify the range of intended seat-to-seat pitch.

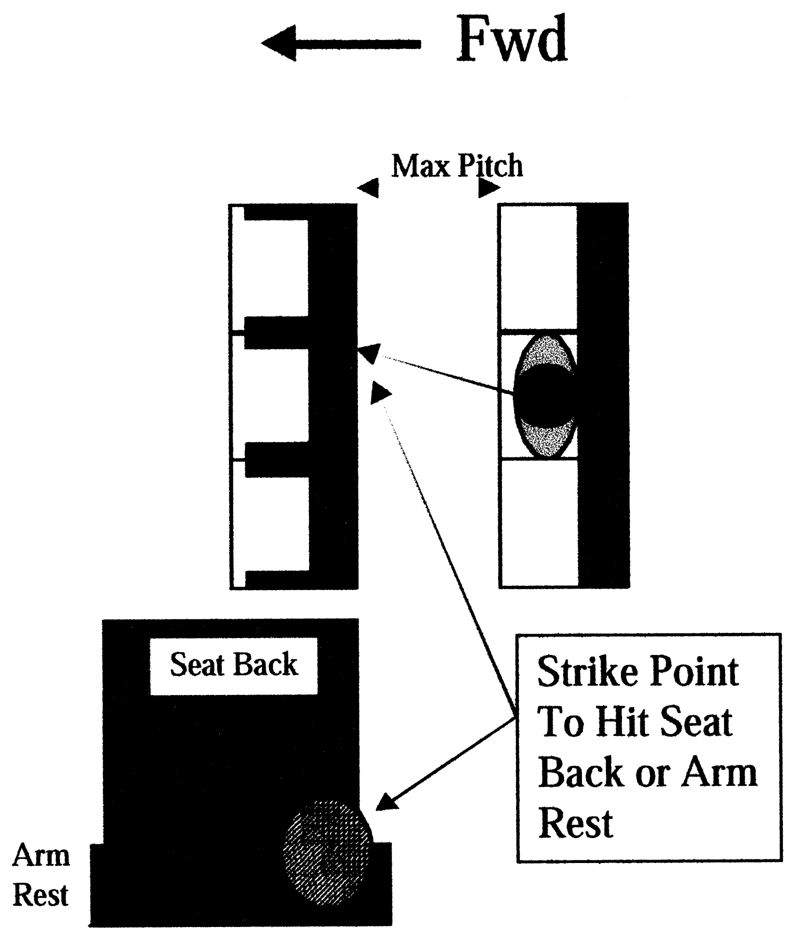
Note: For non-parallel seat installations (i.e., at the seat track break between the airplane constant and tapered sections) the SRP-to-SRP distance at the center of the seat place will be used as the seat pitch to determine minimum and maximum pitch when utilizing this test article selection procedure. All seat places (inboard to outboard) in the seat must be considered when determining the minimum and maximum seat pitch. Additional, unique seat pitches may be considered by choice.

c) For seats installed at an angle with respect to the airplane longitudinal axis (parallel rows or non-parallel rows), e.g., the rows in the tapered section of the aircraft:



i) Determine the head strike location of the 50% male ATD for the seats in the yawed installation configuration (inertia load direction parallel to the airplane longitudinal axis) using the path of the top of the ATD head.
ii) Determine the head strike location of the 50% male ATD for the same seats in a 0° yaw; parallel row installation configuration at the same seat-to-seat pitch as the yawed installation configuration.
iii) Calculate the "head strike offset - the distance between the two contact points determined in steps 1(c)(i) and 1(c)(ii), measured on a plane perpendicular to the airplane longitudinal axis.
iv) If the cumulative offset between the staggered seats plus offset due to the installation angle head is 6.0 inches or less, the additional seat angle may be neglected for the row-to-row HIC tests.
v) If the cumulative offset between the staggered seats plus offset due to the installation angle is greater than 6.0 inches, the additional seat angle must be included in the step 1(d)(i) evaluation and included in the test set up, as necessary.

d) For two of the same part number seats in the family, installed parallel to each other:



i) Determine the maximum seat pitch (within the range identified in step 1(b)) and the yaw angle (within the ±10° envelope plus additional seat installation angle per step 1(c)(v), if required) at which the 50% male ATD head impacts the lower portion of the seat back structure and/or the armrest structure. In most cases, the additional aircraft installation angle is not additive to both the plus and minus yaw angle (e.g. the analysis for an aircraft installation angle may be +10° and -14°).

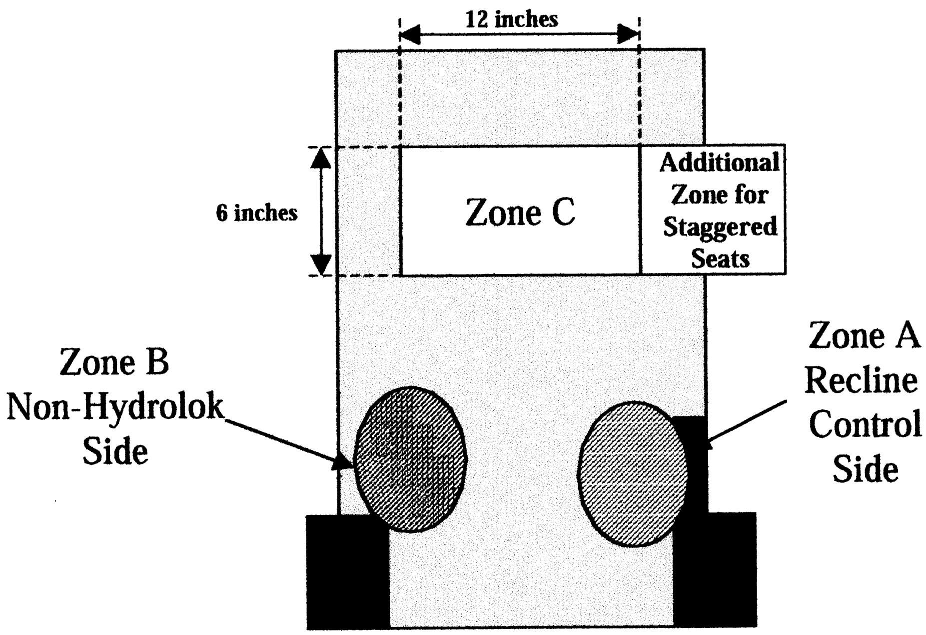
Note: Impact is defined as a solid strike by the ATD head and not a glancing blow.

ii) A test which is set up (seat pitch and yaw angle per step 1(d)(i)) with the yaw direction such that the ATD head strikes the side of the seat back with the seat recline mechanism shall be conducted (Zone A test).

iii) A test which is set up (seat pitch and yaw angle per step 1(d)(i)) with the yaw direction such that the ATD head strikes the side of the seat back without the seat recline mechanism shall be conducted (Zone B test).

Note: It is common for the recline mechanism to be positioned on the left side of some seat backs and the right side of other seat backs of the same assembly. Therefore, the seat-to-seat HIC test for Zone A and Zone B can usually be accomplished in one two row test using two instrumented ATD's with the yaw direction set to effect a head strike in Zone A by one ATD and Zone B by the other ATD. Alternatively, it may be possible to relocate one recline mechanism for test purposes. If this method is chosen, care should be taken to not alter the basic design. The intent of this procedure is to create a mirror image of the actual part, to simplify testing.

e) For same seats used in step 1(d), installed parallel to each other:



i) Determine the point of initial head contact by the 50% male ATD at the minimum pitch identified in step 1(b) and at 0° yaw angle.
ii) Evaluate the area defined by a 6 inch high by 12 inch wide rectangle centered on the initial head contact point for structures that differ significantly from the initial contact point (i.e., telephone handsets, video screens, and oxygen mask container units).
iii) Determine which structure in the 6 inch by 12 inch rectangle is the most rigid in the direction perpendicular to the aft seat back structure.
iv) A test which is set up which produces ATD head contact with the structure identified in step 1(e)(iii) shall be conducted (Zone C test).

Note: Typically, the Zone C test will be conducted at the minimum seat pitch and 0° yaw. However, when the area of concern (as identified in step 1(e)(iii)) is not at the center of the 6 inch by 12 inch rectangle, the relative position of the seats in the two row set up must be adjusted to produce the ATD head contact desired. Lateral offset or vertical adjustment of the seats' relative position will ensure that a comparable head impact velocity as that measured from the normal position Zone C test is achieved, although other methods that achieve the same objective are acceptable.

f) For seats which have staggered seat places, row-to-row:

Note: Staggered seating can result from a change in the number of seat places, different width seat assemblies, or installation on staggered seat tracks to accommodate the airplane taper section.

i) If the row-to-row seat place is staggered, and the cumulative offset between the staggered seats plus offset due to the installation angle is 6.0 inches or less, the lateral offset between the seat places may be neglected and the row-to-row HIC tests identified above may be conducted without including the lateral offset.
ii) If the row-to-row seat place is staggered more than 6.0 inches, the actual staggered installation configuration must be considered. This may broaden the Zone C evaluation window and include more objects to consider for head strike. If a test representative of the actual staggered installation configuration is determined to be required (either in addition to, or in lieu of, one of the baseline tests identified above), the test set-up (yaw direction and angle, and seat pitch) shall be that which is determined to be critical for HIC.

Note: A staggered seat installation may prove to be the critical HIC evaluation for the airplane installation, if contact with armrests or other hard structure occurs. Such an installation may require additional testing beyond the Zone A and B evaluations in step 1(d).

g) For row-to-row HIC tests:
   i) Since this test is not considered the critical case used to demonstrate compliance to structural criteria, non-production seat tracks may be used, for example, steel track, or seat track from a different aircraft type may be used on this test.
   ii) Any seat or seat place that allows the ATD to strike the intended target area is acceptable.
   iii) It is acceptable to conduct the test with no ATD's in the forward seat row. The components attached to the seat back and the structure of the seat back which influence HIC must all be representative of the production seat for all seat backs or armrests which will be contacted by the ATD during the HIC test. This includes the mass/weight of the seat back, breakover mechanism, the structure of the armrest and contact area of the armrest. Other components or parts of the seat may be non-representative or deleted from the test article.
   iv) Weights representing under-seat baggage are not required for either seat row. All components that are part of the seat should be represented, at least, by ballast.
   v) Life vests and weights representing literature pocket contents are not required for the forward seat row.
   vi) A representative floor shall be included in the test set up for the ATD(s) feet.

h) For each row-to-row HIC test, a post test evaluation of the high speed film/video and evaluation of the seat back (e.g., chalk mark) must show that the intended ATD head strike was achieved with regard to location and head impact (solid head strike and not a glancing blow). If the intended ATD head strike was not achieved, an adjustment to the test set up and a retest may be required.

2) Collection of ATD Head Path Data to demonstrate no head contact with aircraft interior features (usually front row seats).

Note: It is acceptable to collect ATD head path data in the 16g longitudinal structural test.

Note: This procedure only selects a test article for the collection of head path data. Additional analysis will be required to assess the specific interior configuration (e.g. translating the yawed head path into aircraft coordinates, evaluating the airplane interior for potential head strikes using the head path data collected.).

For each family of seats:

a) Conduct a 16g longitudinal dynamic test of the seat selected in 16g longitudinal structural test identified in section 4.1 above. If more than one 16g longitudinal structural test is identified in section 4.1, select the seat with the greatest overhang to collect head path. It is acceptable to use the opposite-hand part for this seat.

b) The occupancy used in the 16g longitudinal structural test shall be used for this test.

c) The test will be conducted with no yaw, no pitch, and no roll. Representative seat track is not required for this test, since structural attachment substantiation is not under consideration (e.g. steel tracks may be used on this test).

d) The head path data of the ATD expected to move the furthest forward due to structural deformation (usually in the most overhung seat place) should be collected. The most overhung seat place is the outer (left or right) seat place with the greatest distance from the centerline of the seat leg to the outer edge of the seat.

Note: It is acceptable to conduct additional head path tests of this type on other seats to collect head path data for specific seat places.

It is also acceptable to install a bulkhead, or rigid vertical wall, at the minimum design set back from the bulkhead into the test set-up for the purpose of showing no ATD head contact during the test. It is not required for the bulkhead used in the test set-up or material to be representative of the production aircraft interior component. This is because the test is conducted to establish if head contact occurs for a specific setback distance, and the location of head contact by a 50% ATD in those cases where it does. It is the responsibility of the seat installer to utilize this data to demonstrate an acceptable installation.

e) Baggage, life vests, and literature pocket contents shall be installed at each seat place, regardless of seat occupancy. Items of mass on the seat (e.g. under-seat IFE boxes) may be replaced by ballast.

f) Retention of items of mass need not be demonstrated in this test and items of mass may be restrained for the test.

g) A representative floor shall be included in the test set up for the ATD(s) feet.

3) Large Clearance Installations

   a) Installations behind another seat or interior component where the distance between the seat SRP and the aft-most point on the seat or interior component is greater than 50 inches do not require dynamic test data to substantiate the HIC criteria. This is based on substantial industry data that demonstrates a seat passing structural criteria will not have a head path that extends beyond 50 inches from SRP. Current guidance for head/floor strikes and occupant/occupant strikes is contained in the current HIC-Lite guidance and is considered acceptable.

   Note: Front row HIC compliance is outside the scope of the current task, but should be included in the comprehensive guidance that will be issued for 25.562 compliance.

<u>FAR/JAR 25.562 (c) (6) - Femur Loads</u>

1) Row to Row Femur Data Collection

   a) The ATD in the Zone C minimum seat pitch, 0° yaw of the row-to-row HIC test selected shall be instrumented for the collection of femur loads. Each leg shall be instrumented. Alternatively, previous test data from a similar seat may be used to show compliance with the femur load requirement.

2) Collection of ATD Knee Path Data for Use in Femur Load Compliance (Front Row)

Note: It is acceptable to collect ATD knee path data in the 16g longitudinal structural test. Additional analysis will be required to assess the specific interior configuration (e.g. translating the yawed knee path into aircraft coordinates, evaluating the airplane interior for potential knee strikes using the knee path data collected).

   a) The knee path data of the ATD in the most overhung seat place may be collected during the test that collected head path used to show compliance for 25.562 (c) (5). The most overhung seat place is the outer (left or right) seat place with the greatest distance from the centerline of the seat leg to the outer edge of the seat. An additional test to only collect the knee path data is not required provided it is collected during the same test that collects the head path.

   Note: It is acceptable to conduct additional knee path tests of this type on other seats to collect head and knee path data for specific seat places.

b) The knee path data collected via the high speed film/video will be used show no knee contact with any aircraft interior components in the production installation. If this analysis of the seat installation/interior configuration shows that the knee will strike an aircraft interior component, additional testing which collects the femur load will be required.

3) Large Clearance Installations

Installations behind another seat or interior component where the distance between the seat SRP and the aft-most point on the seat or interior component is greater than 40 inches do not require dynamic test data regarding femur loads.

5.0 Structural Pass/Fail Criteria

The primary load path should remain intact. Yielding for energy absorption is acceptable, and generally desirable. In this sense, yielding is a controlled, predictable deformation, where load carrying capability is maintained. Instability failures in primary load carrying members are not yielding and are not acceptable unless a secondary, predictable stable state is reached.

Some damage to the primary load path is expected and acceptable, however. Damage should be evaluated considering the role of the load carrying element in its critically loaded condition. Damage that might be unacceptable in a rear leg (tension) fitting might be acceptable in a forward leg (compression) fitting, depending on the consequence of the failure mode. Deformation to the extent that rapid egress is not compromised is encouraged. Minor cracking of primary structural elements and separations of some fasteners (a minority of fasteners in a row, for example), or minor delamination can be accepted if the remainder of the structural requirements have been satisfied. That is, the primary load path is intact, the seat remains attached at all points of attachment, and the occupant restraint system remains attached at all points of attachment. Hazardous projections or sharp edges shall not be created and egress shall not be compromised as discussed in current guidance.

For the restraint system, scuffing and fraying or breakage of some fibers is expected and should be acceptable. Tearing or cutting is indicative of a problem and is not a predictable mode of failure. Tears or cuts to the restraint system are not acceptable.

5.1 Test Failures vs. Retest

A variety of different failures can result in an unsuccessful test. Failures can range from structural separation of the seat from the tracks to deployment of items that constitute an impediment to egress. All such failures should be addressed and corrective action taken. However, the necessity to repeat tests following corrective action should be subject to the same sort of decision process that is used to determine which tests are conducted initially.

Failures in any part of the primary load path, including the seat attachment to the track or restraint system attachment to the seat will almost exclusively require retest. Failures in (secondary) internal structure may be able to be addressed analytically. For example, failures in members for which analytical substantiation is acceptable when making the test article selection (using the procedures outlined elsewhere in this concept paper), may not require retest. However, each case should be assessed individually, and a determination made that the failure point would not simply be transferred to another part of the load path. Generally speaking, members for which the failure mode is not catastrophic (e.g., compressive failures in a forward leg, as opposed to a tension failure in an aft leg for a 16g forward test), are less likely to warrant retest. The extent to which a secondary load path(s) can carry the load is a factor in determining the pass/fail of a structural test.

Special attention to the seat structure prior to the removal of floor warpage is advised. Structural failure can occur as a consequence of removal of floor warpage. If it can be determined that the damage or seat deformation occurred solely as a result of, or was caused solely by, removing the floor warpage, it shall not be considered a failure.

The evaluation of the seat attachment should be made before the seat tracks are straightened (unwarped). The process of straightening the seat tracks may result in a seat attachment becoming detached. This is not a failure of the test. The assessment for seat attachment should be made after the restraining force on the pitch-and-roll fixture has been released. It is not necessary to return the floor to a flat condition to evaluate the seat attachment. Once the evaluation for seat attachment has been completed, the floor may be returned to a flat state in order to take deformation measurements (if applicable).

Cuts or tears in a restraint system may not require a retest if it can be demonstrated that the corrective action will be effective, and if all other pass/fail criteria were met on the test in question.

Failures of attachments of items on the seat may be addressed analytically, provided that the corrective action does not impact the primary load path of the seat/occupant system or occupant injury criteria. However, the seat must be shown to be able to carry its full weight, including any attached items. Similarly, items that deploy should not require retests, if the corrective action does not affect the dynamic behavior of the seat or occupant.

In the case of a test that exceeds the minimum test conditions where the test results in a failure, an assessment of the test conditions and the failure mode must be made and a reason for retest without change must be presented to allow a retest without modification.

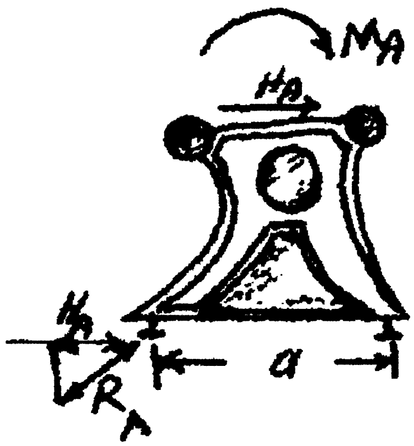
Appendix A - Sample Analysis

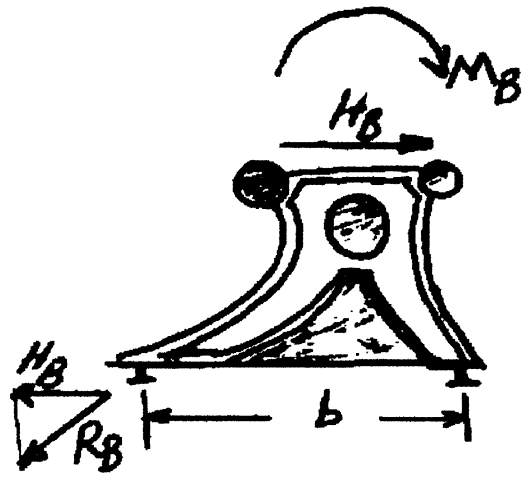
Example:

An example and a thought process of analytically justifying the suitability of a variant of a seat component for inclusion in a family of seats without a full scale test will be presented. The demonstration of the process will relate to a seat with a variation in the seat leg consisting of increasing the fore-aft distance between the front and rear attachment of the leg to the aircraft floor.

Problem Statement:

1. Assume that a family of seats utilizing a leg (Leg A) with a certain leg pitch has been defined and certified.
2. The critical seat based on maximum reaction load has been established using the calculated interface loads derived in an acceptable manner. This seat, where leg A is the critical seat of the family based on reaction loads, has been tested.
3. A new configuration presents itself wherein all primary structural components except the leg, Leg B, of the seat belong in the family established by test. Leg B which has not been tested possesses sufficient commonality with Leg A, based on the criteria and methodology presented in Section 3.0 that an analytical evaluation is justifiable using the methodology below:
4. A schematic representation of Legs A and B are shown below. Shear load H and moment M schematically represent applied loads to the legs. For clarity only the resultant reaction at the rear attachment to the aircraft track is shown, represented by R whose horizontal component reacts load H :





$a \leq b$

LEG A
Longitudinal Loading

LEG B
Longitudinal Loading

Solution Part I, Longitudinal performance:

1. $R_A > R_B$ has been determined from an interface loads analysis for the forward longitudinal loading condition (otherwise a test would be required). The values for applied loads H, M or equivalent load input information would be based on the interface loads analyses that yield R_A and R_B.

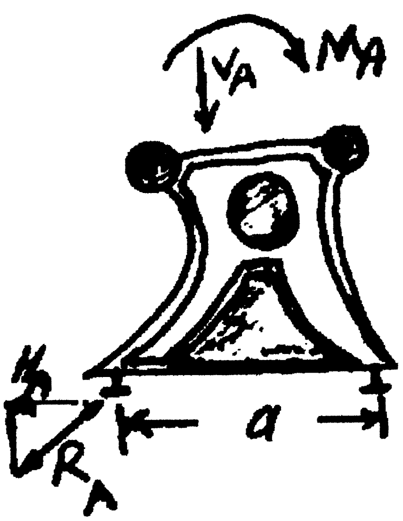
2. Perform a stress analysis of Leg A to determine internal stresses/strains under loads H_A and M_A. Similarly, perform a stress analysis of Leg B to determine internal stresses/strains under loads H_B and M_B.

3. Verify, or adjust the design of Leg B as required, so that no stress/strain in Leg B is greater than in Leg A location for location within the seat leg. Attachment hardware should be included in this verification.

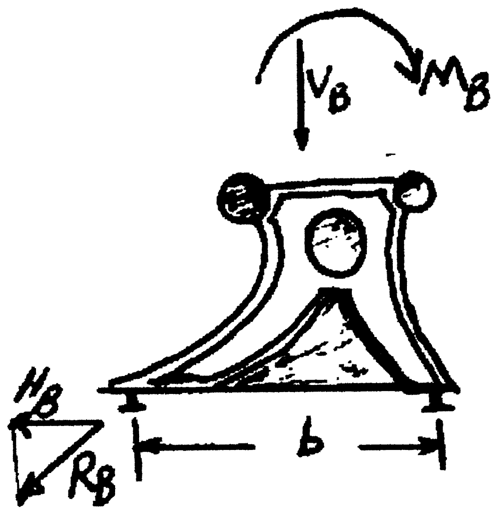
   If hand calculations are used, this requirement can involve substantial effort to demonstrate that the critical stress/strain location(s) are known and that as a result of the design change the stress/strain distribution of the new design has not changed. A global evaluation method (e.g. finite element) will determine the total stress state of the part overcoming that difficulty.

4. Calculate the forward deflection of the structure at the waterline at which H_A and H_B are applied. The deflections d_A and d_B are calculated for Leg A under H_A and M_A loading and for Leg B under H_B and M_B loading respectively. Calculate the longitudinal stiffness K_A of Leg A, and K_B, the longitudinal stiffness of Leg B wherein $K_A = H_A/d_A$ and $K_B = H_B/d_B$. Verify, or adjust the design of Leg B as required, that $K_B \leq K_A$.

Solution Part II, Vertical performance:



LEG A
Vertical Loading



LEG B
Vertical Loading

1. Perform an interface load analysis of the two seats in question to establish R_A and R_B under a vertical load condition.

2. If not obvious by comparison or from the results of solution Part I step 2; perform a stress analysis of Leg A to determine internal stresses/strains under V_A and M_A. Similarly, perform a stress analysis of Leg B to determine internal stresses/strains under V_B and M_B loading. V_A and M_A are the input loads resulting from the interface loads analysis of the seat with leg A. V_B and M_B are the input loads resulting from the interface loads analysis of the seat with Leg B.

3. Verify, or adjust, the design of Leg B as required, so that no stress/strain in Leg B is greater than in Leg A location for location within the seat leg. Attachment hardware should be included in this verification.

   If hand calculations are used, this requirement can involve substantial effort to demonstrate that the critical stress/strain location(s) are known and that as a result of the design change the stress/strain distribution of the new design has not changed. A global evaluation method (e.g. finite element) will determine the total stress state of the part overcoming that difficulty.

4. Calculate vertical deflection d_A for Leg A and vertical deflection d_B for Leg B at a fore-aft station aligned with the CG of the occupant used in the interface load analysis for vertical loading. The deflections d_A and d_B are calculated for Leg A under V_A and M_A loading and for Leg B under VB and M_B loading respectively. Calculate K_A, the vertical stiffness of Leg A, and K_B, the vertical stiffness of Leg B wherein $K_A = V_A/d_A$ and $K_B = V_B/d_B$. Verify, or adjust the design of Leg B as required, that $K_B \leq K_A$.